INSIDE VIEW OF A STAR PARTY

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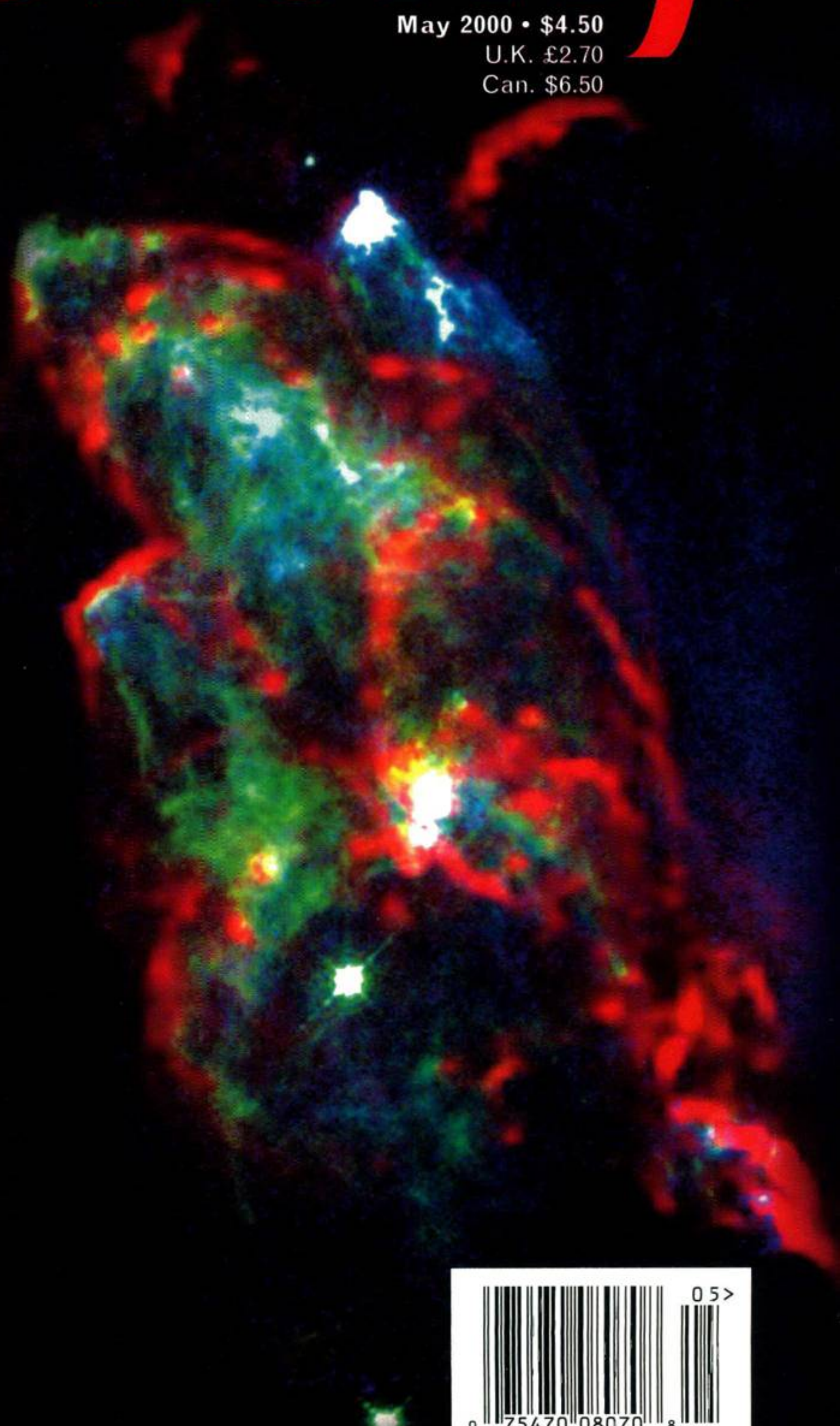
Unraveling a Mystery

How Stars Get Born



Tracking Down Gamma-Ray Bursts

Bushnell Review:
Déjà Blue?

In Search of ET

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New Low Prices!

MEADE LX200

8" LX200
$2295
10" LX200
$2695
12" LX200
$3995

The largest-selling serious telescopes in the world are now available at the most affordable prices *ever!*

The exact same LX200's as before: not one specification has been changed. **Compare a Meade LX200 feature-for-feature with competing single-tine-fork, spur-gear-driven, GO TO Schmidt-Cassegrains.** You'll see why there really is no comparision:

- **Superb Optics:** With oversize primary mirrors for greater full-field illumination, LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Competing 8" Schmidt-Cassegrains claim to place objects "somewhere in the field of view;" Meade LX200's place objects **dead-center** in the field of view, first time, every time, to a pointing precision of **2 arc-minutes or better,** or, with Meade-exclusive High Precision Pointing, to a precision of **one arc-minute or better.** *Meade LX200's are the only commercial telescopes ever manufactured that automatically GO TO any input R.A. and Dec., or to any object in the onboard database, to these levels of precision.*
- **Database of 64,359 Objects,** a database *more than three times larger* than competing GO TO telescopes.
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc-sec. periodic error, an observatory standard. Competing GO TO 8" SCT's decline to state their periodic error and do not offer any programmable error-corrector.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every contingency of telescope posi

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Meade
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Meade 8" LX200 Schmidt-Cassegrain Telescope — now $2295, complete.

tioning — from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between. Competing 8" SCT's slew only up to 6.5°/sec.

- **Rigid LX200 Dual-Tine Fork Mountings with Dual 5.75" Worm Gears** are the choice of advanced observers, CCD imagers, and astrophotographers for their most sensitive applications. Competing spur-gear-driven single-tine forks can not approach the strength, rigidity, and drive-rate precision built into every Meade LX200 mounting.

- **Full Long-Exposure Capability:** Competing 8" GO TO telescopes describe their capability to take short-exposure "planetary and terrestrial photos," without reference to any long-exposure capabilities. Meade LX200's have been the instruments of choice in **thousands** of the most detailed long-exposure images ever taken by amateur astronomers.

- **Strong Field Tripods:** Unlike the thin, extruded aluminum tripods of competing models, every LX200 includes a fully adjustable steel field tripod perfectly suited to the sub-arc-second resolution of the telescope's optics.

"...Viewing a 2nd-magnitude star at high power [the 8" LX200] showed a nearly textbook-perfect image...I do indeed rank these optics as diffraction limited...Jupiter and Saturn exhibited riveting detail... During the November 10, 1997, triple shadow transit on Jupiter, the LX200 was my telescope of choice. It showed all three moon shadows as plainly different in size and shading, a rare and remarkable sight. Under the automatic GO TO command, the LX200 routinely placed objects, including the Moon and planets, within 1 to 4 arc-minutes of the center of the field. Not only was it accurate — it was fast. The LX200 usually took no longer than 10 to 25 seconds to slew to and center an object...The latest major feature added to the system is what Meade calls High Precision Pointing. When this is activated...Meade promises a pointing accuracy of 1 arc-minute. I can confirm this amazing figure. Objects consistently ended up within 1 to 2 arc-minutes of the field's center, a great aid to CCD imaging of faint targets...if you know what you want to look at, the LX200 will find it with astonishing speed and accuracy...the telescope I tested provided excellent performance in all critical areas while adding a level of technical luxury that is truly powerful and impressive...I have absolutely no hesitation in recommending the LX200 series...After having used the LX200 for several months, I can attest to the wonderful hands-off convenience and sheer fun of the motorized GO TO." — **from the review in *Sky & Telescope*, April, 1998.**

"The [10" LX200] telescope's optics, stability, and tracking accuracy — all of which are crucial in my applications — are truly remarkable, fully up to the demands that my photographic program requires. My LX200 is now nearly four years old, and during that time it has received heavy use, including 2000-mile round trips to southern France four times a year. The telescope is everything I could possibly have expected it to be." — **Philip Perkins, Wiltshire, England**

The Whirlpool Galaxy (M51) in Canes Venatici.
A 10" LX200 photo by Philip Perkins; two 120-minute exposures were digitally combined to obtain the final image.

"The view through the [7" LX200] system is superb, with pin sharp images right across the field and absolutely no trace of achromatism. Moving to higher powers reveals stellar images constrained only by the seeing and limitations of diffraction.... This telescope is, by any standards, a most powerful observing system.... If you were to sit down and write a specification based on unbridled optimism and imagination, I doubt whether you would come up with all of the features available on the LX200 series. This telescope really has to be experienced." — **from the review in *Astronomy Now* (U.K.), November, 1996, by Bob Neville, Director, Instruments and Imaging Section, British Astronomical Association.**

"The optics of my 12" LX200 are exquisite — in fact the best optics in a commercial catadioptric telescope that I have ever looked through. At 500X the Epsilon Lyrae double-double is not only clearly split into four components, but each of the four stars exhibits a textbook-perfect diffraction pattern, the ultimate test for superior optics." — **Jack Newton, Chiefland, FL.**

SPECIFICATIONS: 7", 8", 10", and 12" LX200's — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC (optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug); 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2295.**
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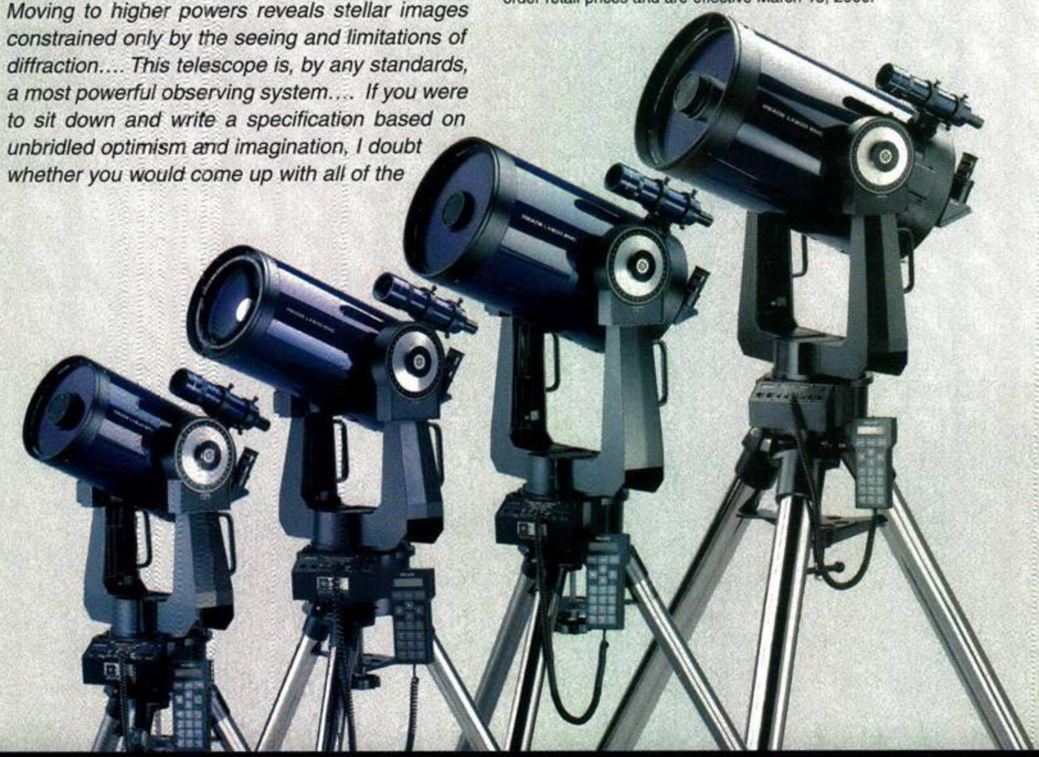
7" LX200 Maksutov-Cassegrain	**2795.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125. Prices shown are suggested U.S. mail-order retail prices and are effective March 15, 2000.



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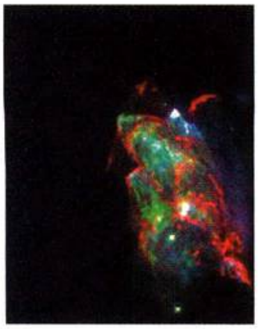

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COVER PHOTO: Patrick Hartigan (Rice Univ.) Jon Morse (Univ. of Colorado), et al., and NASA

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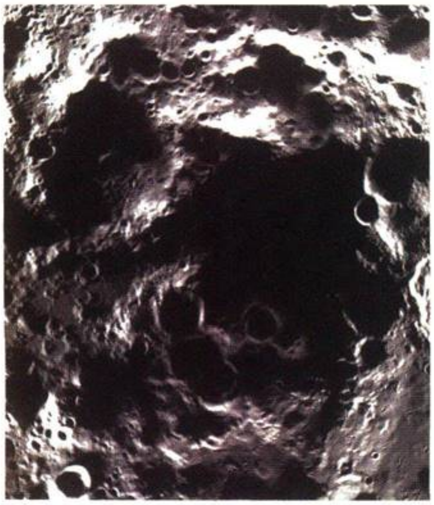

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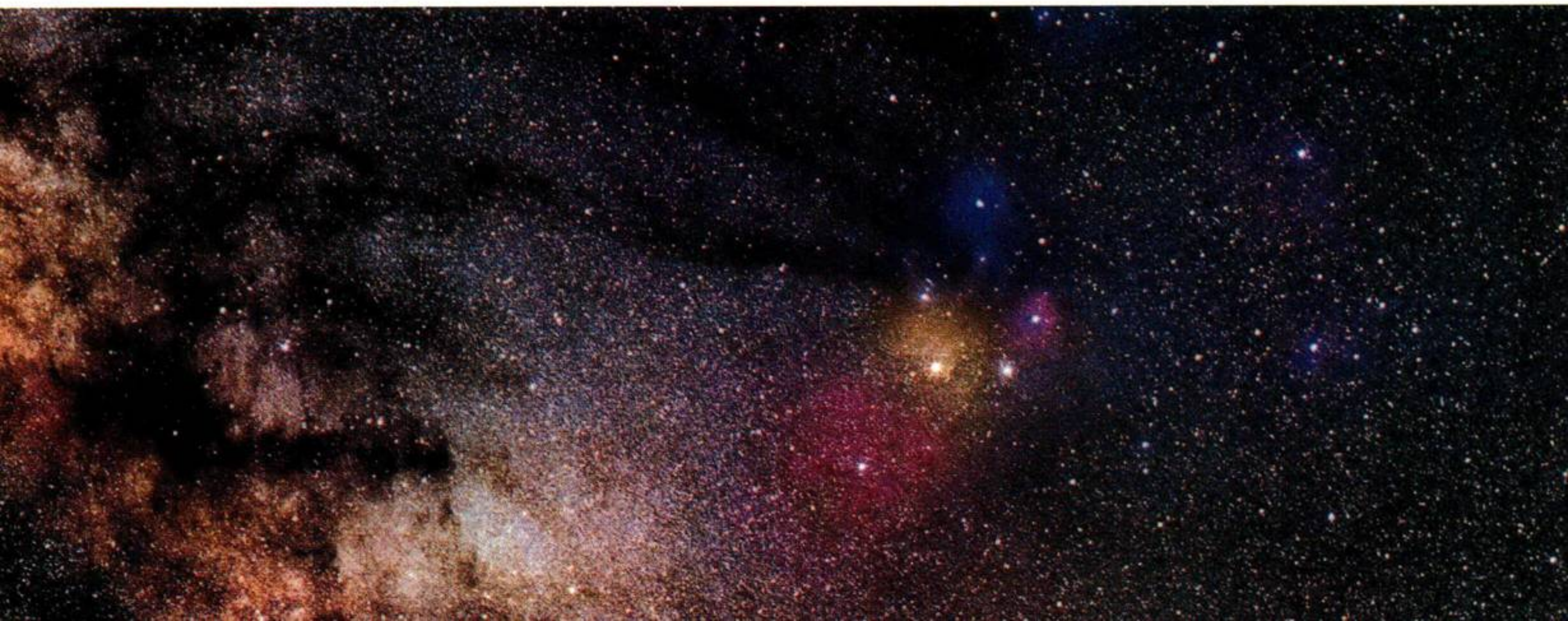


BEHIND THE SCENES

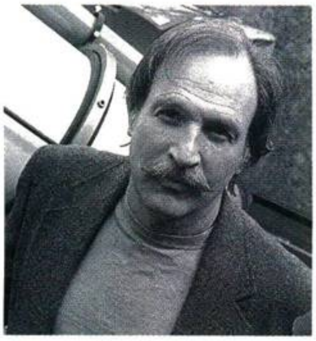
BY BONNIE BILYEU GORDON

Fast Forward

A year ago, the gamma-ray-burst detector on the orbiting Compton Gamma Ray Observatory caught signals that indicated a high-energy explosion. Within 26 seconds a robotic telescope in Los Alamos, New Mexico, captured the first visible-light images of the life of an ephemeral gamma-ray burst. Though we had seen the afterglow of a burst before, we were never able to point telescopes quickly enough to see the event, perhaps the most powerful in the universe.

In 1920, the universe was limited to our Galaxy. We didn't acknowledge a thing beyond that.

In 80 years, technology has grabbed us and dragged us into revelations so immense they are difficult for the average Jill to comprehend. But nowhere has technology evolved at the clip it has in astronomy. A more detailed view of this technology comes from Robert Zimmerman on page 36 with his story on the gamma-ray capture. This is serious business and ordinary people have to work hard just to ask intelligent questions about it.


Bob Berman

In the midst of such seriousness, I've tried for three years to include some humor in the pages of *Astronomy*. Sometimes it misfires a bit: Our most successful humorist, Bob Berman, offended some witches in his October column on sinister sights of the autumn skies. In a column in this issue, he will surely offend those who take astrology in deadly earnest. But his position on this is pretty much shared by the scientific community and the editors of *Astronomy*. We don't want you to plan your personal future on the constellations, and if you do, don't come crying to us.

We often agree with Bob, who tackles many serious topics with either a light heart or a tongue in cheek. We can count on him for the future, as he will be writing a monthly column called Strange Universe. Look for it on page 93. It's our hope that you'll look forward to more.

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8" LX10

8" LX10 DELUXE

The optical performance of a Meade 8" LX200 Schmidt-Cassegrain...for only *$995!*

8" LX10: For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *Standard-equipment includes:*

Super-Multi-Coated Optical System: The *exact same* multi-coated 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. **Series 4000 SP26mm eyepiece:** Complements the exquisite imaging of Meade 8" SC optics. **Equatorial Fork Mounting:** The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. **Cordless, DC-Powered Electronic Motor Drive:** With electronically-regulated DC servo motor for automatic *sidereal-rate* tracking; powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours. **Worm-Gear System:** The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging. **Hand Controller:** Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); SP26mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions. **$995.** (+ $65 packing & shipping in the 48 states)

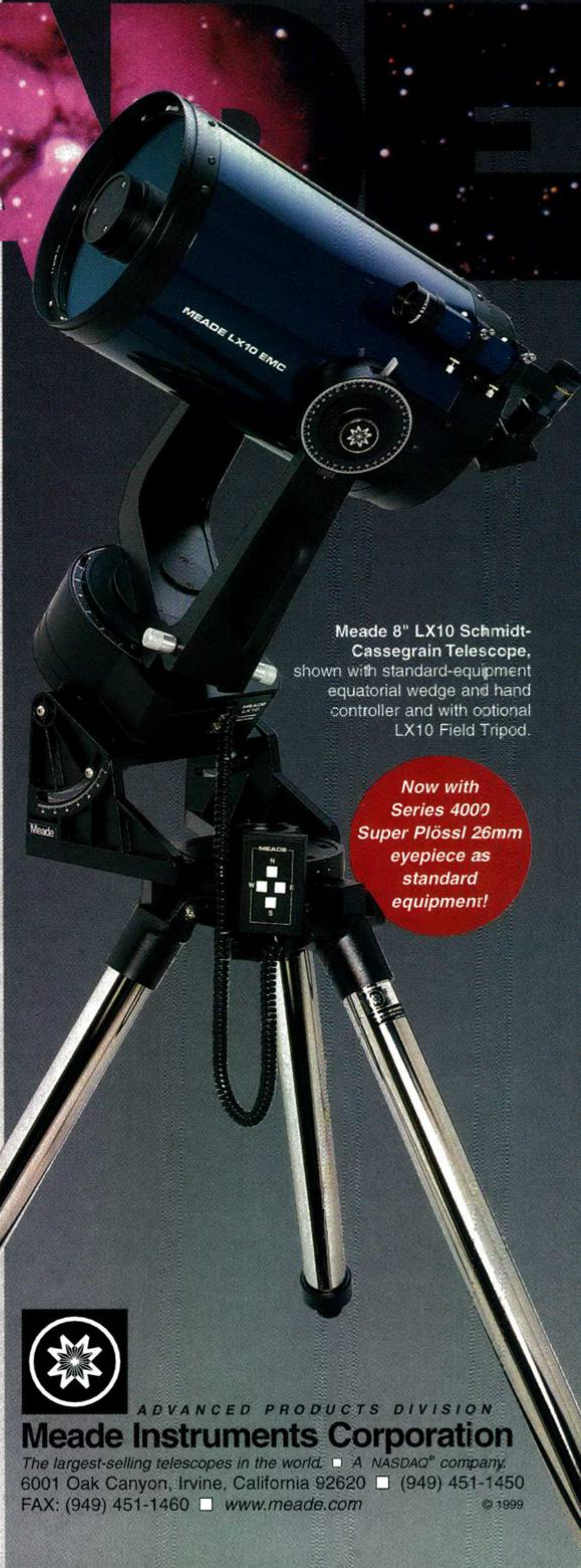
8" LX10 Deluxe: At only $1149 the 8" LX10 Deluxe includes (a) the large-aperture Meade #544 8 x 50mm viewfinder (in place of the standard 6 x 30mm finder); (b) the LX10 Electric Declination Motor System, permitting dual-axis guiding corrections at 2x speed; and (c) Meade Epoch 2000 Jr. Sky Software with 10,000-object database — all at substantially lower cost than if the respective accessories were purchased separately.

SPECIFICATIONS: 8" Model LX10 Deluxe — Identical in all specifications to 8" Model LX10, above, but with Electric Declination Motor System provided as standard equipment, permitting dual-axis corrections at 2x speed; Meade #544 8 x 50mm achromatic viewfinder in place of 6 x 30mm viewfinder; and Meade Epoch 2000 Jr. Sky Software with 10,000-object database.

$1149. (+ $65 packing & shipping in the 48 states)

Field Tripod for LX10 or LX10 Deluxe	195.
Electric Declination Motor System for LX10	95.
#2014 Magellan I Telescope Computer System for LX10 or LX10 Deluxe, with 12,218-object database	375.

The 120-page Meade General Catalog is available free of charge from Meade Instruments or from authorized Meade dealers.
Prices shown are suggested U.S. mail-order prices.



Meade 8" LX10 Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

Now with Series 4000 Super Plössl 26mm eyepiece as standard equipment!

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■ **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel.

■ **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A.

■ **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below).*

■ **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

■ **Massive LX200-type Fork Mounts:** Manufactured of the same aluminum castings as Meade LX200 models. Massive, rigid mounts that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications.

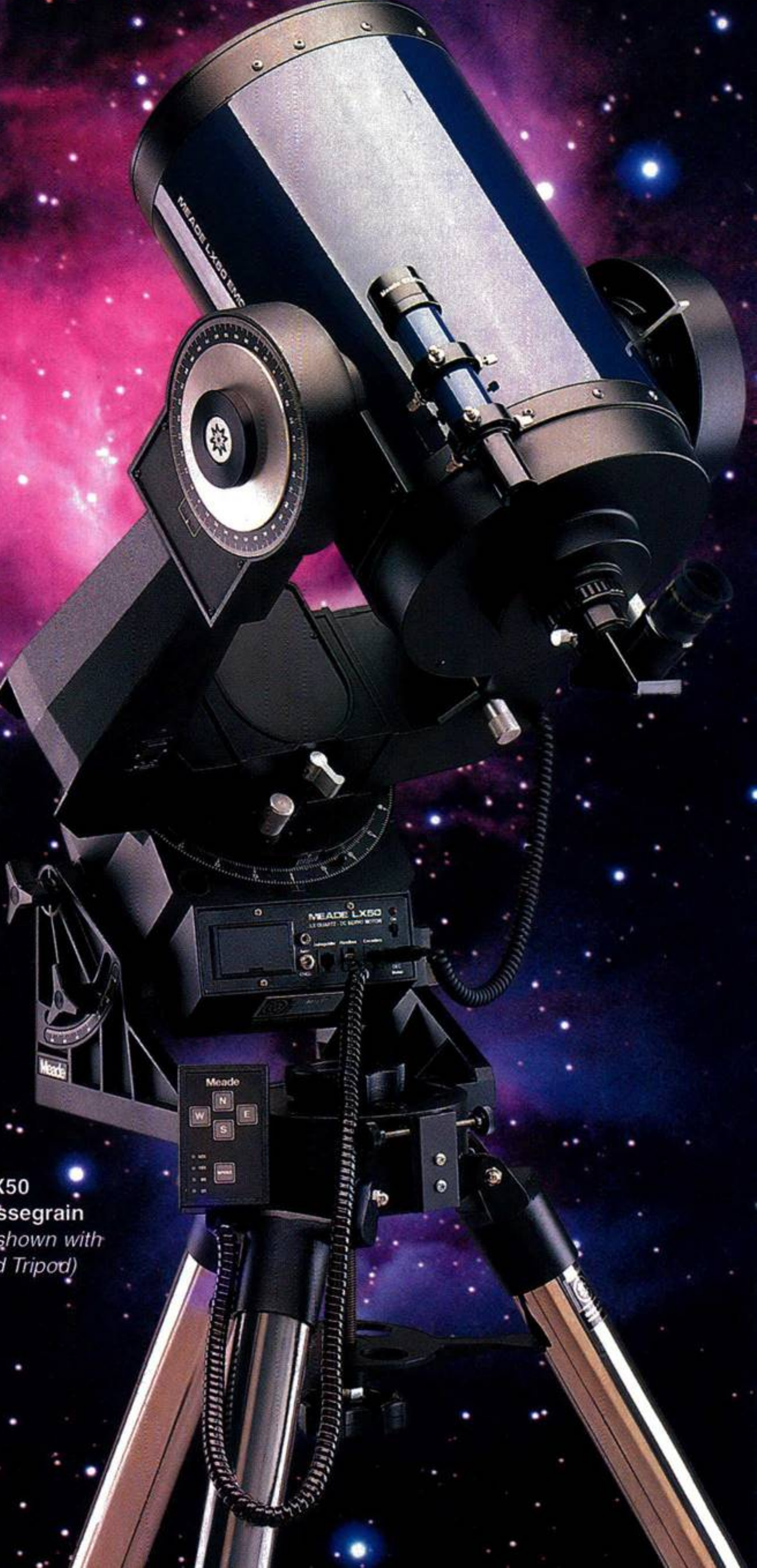
SPECIFICATIONS: 7", 8", and 10" LX50's — Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl *26mm multi-*coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(shown above)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.



Meade 8" LX50 Schmidt-Cassegrain Telescope *(shown with optional Field Tripod)*

MEADE LX200

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MEADE LX200
SMART DRIVE
Meade
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Meade 10" LX200
Schmidt-Cassegrain
Telescope

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models combined. *Standard-equipment includes:*

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*
- **LX200 High-Precision Pointing**™ is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive**™ routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The compact, optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

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Meade® Starfinder 10" Dobsonian ...now only *$449!*

Complete with 1.25" rack-and-pinion focuser, 5 x 24mm viewfinder, Super Plössl 26mm eyepiece, and premium-grade Pyrex® optical system.

Shown with optional #2010 Magellan I Computer System.

The lowest prices *ever* for Meade Starfinder Dobsonians — complete with these standard features:

Series 4000 SP26mm Eyepiece (1.25"): This $80 eyepiece permits all Meade Starfinder Dobsonians to perform absolutely to their maximum capabilities.

Professional-Grade Optical System with hand-figured optics of Grade-A fine-annealed Pyrex glass, *unlike the plate glass optics of other Dobsonians that can become thermally unstable.* Optics are multi-coated and meet the theoretical limits of resolution.

Rigid, Durable, Beautiful Dobsonian Mountings: Zero-backlash Teflon/Nylon bearings facilitate the quick location and easy tracking of celestial objects with extremely smooth motions of the telescope in both altitude and azimuth.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: Strong, spiral-wound Sonotubes™ with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! Every Starfinder model opens up the skies to an extremely wide range of serious visual observing: all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets *in stunning high-resolution detail.* Starfinder Dobsonians are for visual observing; motor-driven Starfinder Equatorials may also be used for lunar and planetary photography, and even for limited deep-space photography.

Meade Starfinder Dobsonian Telescopes

Complete per specifications above:			
6" f/8	$249	**10" f/4.5**	449
8" f/6	349	**12.5" f/4.8**	795
		16" f/4.5	1195

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

Dobsonian Deluxe Accessory Package...only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

Meade #77 2" Giant Rack-and-Pinion Focuser, with eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*

Meade #637 6 x 30mm Achromatic Viewfinder, with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*

Meade Series 4000 Super Plössl 9.7mm and 26mm multi-coated eyepieces — premium-grade eyepieces for high-resolution lunar, planetary, and deep-space observing. *(reg. $79.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $269.80!

Meade Magellan I Telescope Computer System

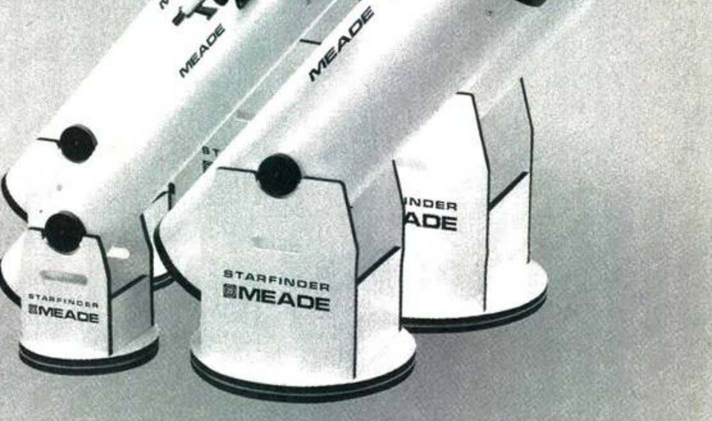
Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

MEADE
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple. **#2010: for Meade Starfinder Dobsonian 6", 8", 10", 12.5", or 16" — $295.** Packing & shipping in the 48 states—$15.

Note: Many manufacturers compromise telescope performance by using low-cost plate glass — glass which can become thermally unstable — in their primary and secondary mirrors, or else they charge a premium for Pyrex optics. *Meade Starfinder Dobsonian and Equatorial telescopes include Pyrex glass, exclusively, at no additional cost.*



Meade® Starfinder 8" Equatorial with Motor Drive... *now only* ***$599!***

Complete with giant rack-and-pinion focuser for 1.25" and 2" eyepieces, 6 x 30mm viewfinder, Super Plössl 26mm eyepiece, and premium-grade Pyrex® optical system.

Shown with optional #2011 Magellan I Computer System.

Precision, heavy-duty equatorial mounts with DC-powered drive systems for fully automatic tracking.

Professional-Grade Optical System: Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Accessories and Components: Premium-grade multi-coated SP26mm eyepiece (1.25"); 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System: For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries or from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 1.25" and 2" eyepieces.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 giant focuser.

Meade Starfinder Equatorial Telescopes

6" f/8	$499	10" f/4.5	699
8" f/6	599	16" f/4.5	2695

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

To Order any Starfinder model: contact your authorized Meade Advanced Products Dealer, below. Prices shown are suggested U.S.A. mail-order retail prices.

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 570-842-1500.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders/Info: 800-621-2248; IL: 312-332-2000.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

Magellan I Telescope Computer System: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page)*.

#2011: for Meade Starfinder Equatorial 6", 8", or 10" . . . . . $295.
#2012: for Meade Starfinder Equatorial 16". . . . . 295.

Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

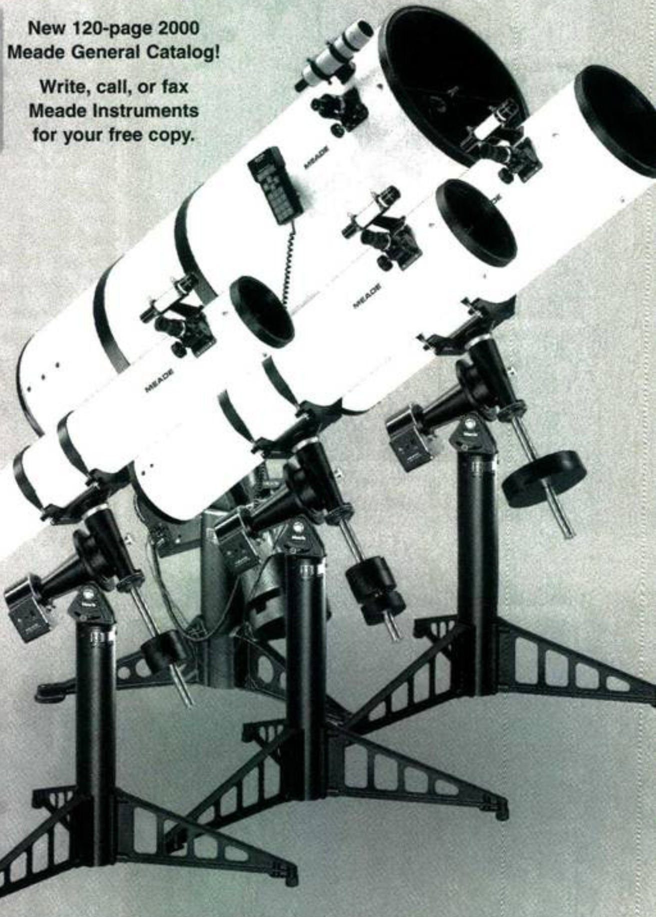
#2018: for Starfinder Equatorial 6", 8", 10" . . . . 495.
#2019: for Starfinder Equatorial 16" . . . . 595.

Packing & shipping in the 48 states: Magellan I – $15, Magellan II – $20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece ***for only $29.95!*** *Purchased separately, the SP9.7mm eyepiece sells for $79.95.*

New 120-page 2000 Meade General Catalog!

Write, call, or fax Meade Instruments for your free copy.



ADVANCED PRODUCTS DIVISION

Meade Instruments Corporation

The largest-selling telescopes in the world. ☐ *A NASDAQ company.*
6001 Oak Canyon, Irvine, California 92618 ☐ (949) 451-1450
FAX: (949) 451-1460 ☐ *www.meade.com*

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RESEARCH-GRADE ACCESSORIES

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Plössls 52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (4.54)
32mm (52°); **40mm** (44°)	each:	**99.95** (5.26)
56mm (52°; 2")		**199.95** (7.02)

Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

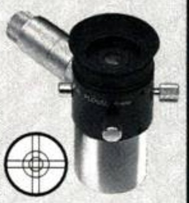
Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece



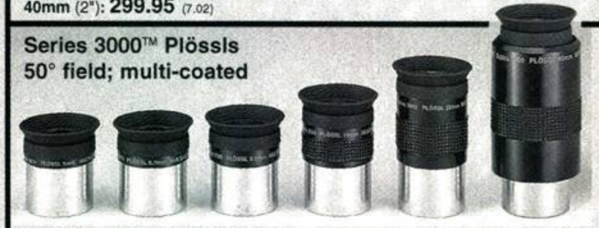
Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 3000™ Plössls 50° field; multi-coated



Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

#911X
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (4.54)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. **$149.95** (7.48)

#1205 Electric Focuser: For all other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

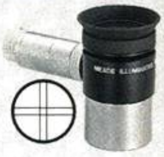
$169.95 (7.88)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (4.54)

MA12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

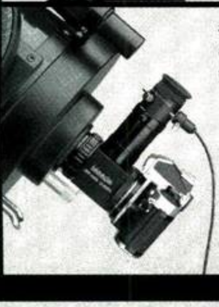
$39.95 (3.86)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930**, each: **$99.95** (6.85)

#777 Off-Axis Guider for SCT's



Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

$79.95 (6.85)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

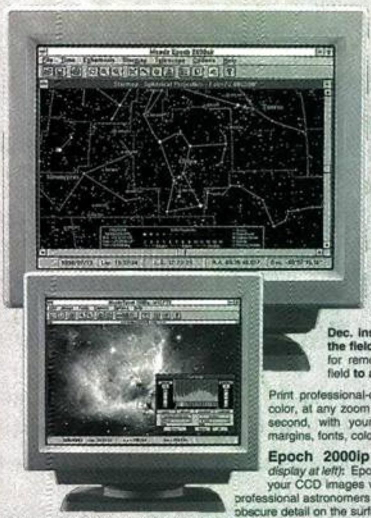
#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-8; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

#644

#647

MEADE
FLIP-MIRROR SYSTEM



Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $149!

Epoch 2000sk *(upper display at left)*: Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** the Trapezium in Orion is no longer shown as a single point, as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software *(lower display at left)*: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

EPOCH 2000sk Sky Software: 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95	**$149**
EPOCH 2000sk-CD Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM	**179**
LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk	**25**
EPOCH 2000ip Image Processing Software: Supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95	**$199**

f/3.3 CCD FOCAL REDUCER

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

NEW!

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

NEW!
MEADE
PLÖSSL
CCD FRAMING

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **$129.95** (4.54)

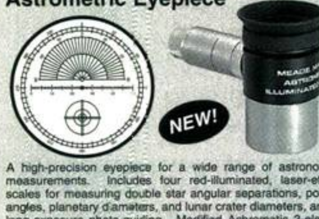
#825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing. **$49.95** (4.26)

#64 T-Adapter for ETX®

Threads to the photo port of all ETX-90 and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **$34.95** (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece



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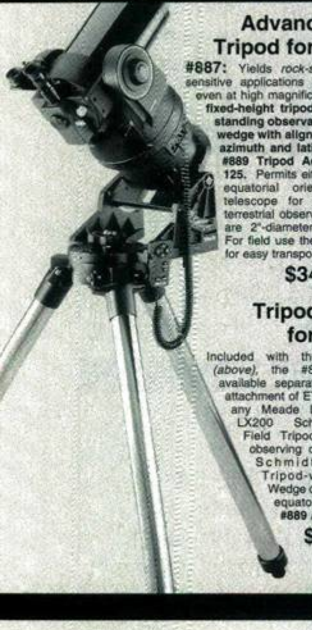

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Gravity Slows Expansion

I'm perplexed by two statements in the March issue. On page 54 in the second paragraph of the sidebar "An Inconstant Constant," the conclusion, "If gravity were acting alone [in slowing the expansion of the universe] . . . the universe is younger than it would be without gravity" is difficult to absorb. Does it mean that if there were no gravity we would measure an older universe than we do now? Also, on page 73 in "Reaching for the Sun" (second column, fourth paragraph), " . . . the dark lines occurred when light absorbed atoms" is incorrect, right? — *Christian Foy, Guilford, Connecticut*

Let's answer the second question first: Yes, the sentence should read, "the dark lines occurred when atoms absorbed light." Thanks for catching that error. Next we'll tackle the more confusing question about gravity and the universe's age: Intuitively, one might think the exact opposite, but the short answer to your question is "Yes." Gravity acts like a brake, causing the expansion of the universe to slow down. This slowdown has a cumulative effect: The universe will expand slower tomorrow than it does today and even more slowly the day after next, etc. Therefore, the universe expanded faster yesterday than today, so the expansion rate was faster in the past than it is today. That's what creates an "Inconstant Constant." Without gravity, the expansion rate would be faster, meaning it wouldn't take as long for the universe to reach its present size. So yes, our universe would be "older" without gravity. — Astronomy editors

The Crab Nebula provoked questions. Jack Newton

Persistence Personified

In 1966, when my interest in astronomy was just beginning, I heard about the November Leonid meteor shower and the possibility of a meteor "storm" that year. I was living in Berkeley, California, and late that night I climbed up onto the roof of my apartment to see what all the fuss was about. As is typical at that time of year, it was completely overcast, and I couldn't see a thing.

The next day I read accounts boasting "200,000 meteors an hour," and "So much light you could read a newspaper at midnight," and so on. I cursed my bad luck and vowed that 33 years later, I would travel to wherever necessary to see the next Leonid meteor storm.

In the intervening years, my wife and I flew to Australia to see Halley's Comet, to Baja California for the solar eclipse, and to Alaska in the winter to see the Aurora Borealis.

As the 1999 date grew near, all the experts agreed that western Europe offered the best chance of viewing success. My family and I trooped off to Ravello, a beautiful little town on the Amalfi coast in southern Italy.

A few days before the shower was due, CNN predicted rain. We left Ravello and drove to Caserta, a bit farther north, but more importantly, close to main highways, which would enable us to travel in all directions to get around the cloud cover. More bad news. A massive rain cloud covered the entire country. Avoiding the overcast sky was impossible.We went to bed early, setting the alarm to wake us every hour. Finally, at about 2 A.M., we gave up, never having seen even one shooting star.

I took the keen disappointment in stride. My wife was amazed. "I thought you'd be screaming and tearing your remaining hair out," she said. I shrugged my shoulders and replied, "Maybe it's just not my destiny to see the Leonid meteor storm."

Besides, when it comes around again in 2032, I'll only be 89. — *Rich Abrams, Tarzana, California*

The One and Only

An October 1999 article about Nebula 44 (page 30) refers to "the distribution of hydrogen atoms that have each lost one or more electrons." Please tell me how many hydrogen atoms have more than one electron? — *Frank Winecoff, Atlanta, Georgia*

Touché! Our faces are as red as Nebula 44! — Astronomy editors

Technically Crabby

A March 2000 AstroNews article said the Crab Nebula formed 1,000 years ago and was 6,000 light-years away. In my eighth grade science class, we learned differently. If an explosion occurred 1,000 years ago and was

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1,000 light-years away, we'd see it 1,000 years after it happened. So if the Crab Nebula formed 1,000 years ago, how could it be 6,000 light-years away? — *Jonathan Miller, Newton, Massachusetts*

Jonathan wasn't the only reader who pointed out that our statement on the timing of the supernova and its distance seemed out of whack. It's true that the supernova was seen on Earth nearly 1,000 years ago and that its progenitor star lies some 6,000 light-years away. Those who wrote came to the logical conclusion that the explosion must have occurred roughly 7,000 years ago.

The reason we stated it the way we did goes back to a problem ubiquitous in astronomy: Every event occurs before it is seen. To give technically precise information on every event we report, most stories would be at least 10 percent longer, and the added material would be arcane to most readers. For example, in that same article, we say the pulsar spins 30 times a second. That's what we observe, but it has been slowing down in the 6,000 years since the radiation left. To be technically precise, we would need to explain how the rotation rate changes with time and what we would expect it to be 6,000 years from now.

So in just one paragraph, we have two instances where qualifying statements are necessary to make the story technically precise. And that's not the worst of it. In Sky Show we often talk about an object's brightness, size, position, illumination, and distance — all of which change depending on how long it takes the light to reach us.

In an effort to keep the magazine at a reasonably nontechnical level, we almost always use the time of arrival on Earth to describe events. Only in cases where we have plenty of room to explain the difference do we go into a more precise definition. — Astronomy *editors* ■

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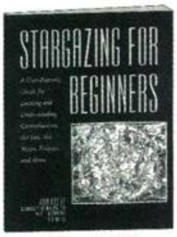

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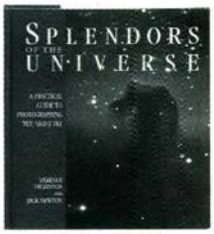

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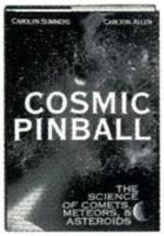

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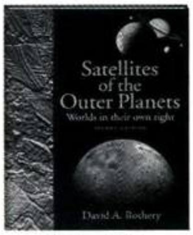

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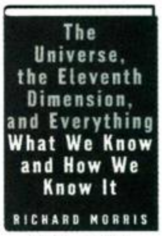

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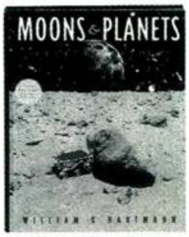
Richard Morris



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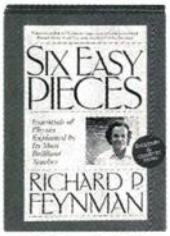

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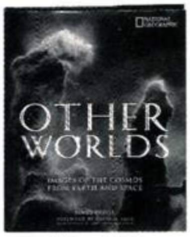

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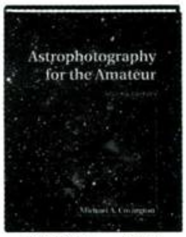

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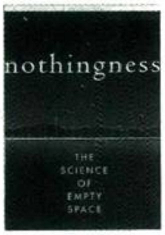

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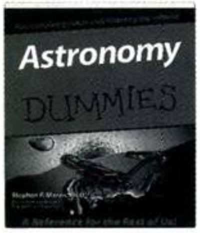

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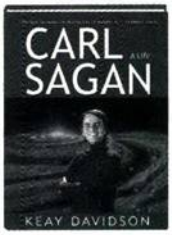

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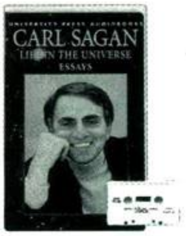
Keay Davidson



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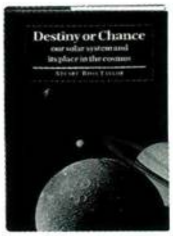

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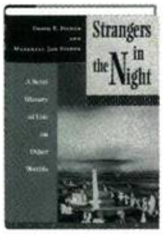

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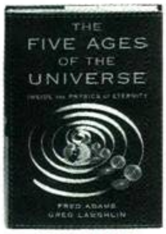
D. Fisher & M. Fisher



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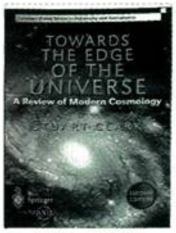

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Astronomy 5/00

The Universe Is Full of Mysteries.
Using NexStar™ Isn't One of Them.

The joy of stargazing comes from observing the wonders of the heavens, not calculating alignments and positioning. The revolutionary new Celestron NexStar 5 does all that for you and more. Simply and easily.

NexStar 5 is light years ahead of other computerized GOTO telescopes, with Auto Align to get you up and observing immediately and an enormous object data base that includes more than 18,000 celestial sights.

Our Star Pointer Finderscope lets you quickly find any object in the sky, while variable slew speeds provide easy tracking for observation and astrophotography. You can attach our Hand Controller to the telescope's unique fork arm, or hold it for remote operation. There's even a communication port so you can control the NexStar 5 from your computer.

NexStar 5 is designed to go with you anywhere and perform beautifully. The legendary 5" Schmidt-Cassegrain optical system with Starbright® multicoatings guarantee superb views. Best of all, our Tour Function automatically seeks out the most spectacular objects in a given month, while providing you with fascinating facts through the Hand Controller.

If you're looking for a telescope that makes astronomy pure joy and fun, there's no mystery about which one to choose. **Celestron's NexStar 5.**

CELESTRON®

Find out more about NexStar 5, our other exceptional telescopes, and nearby dealers. www.celestron.com
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The NexStar™ Just Got Brighter!

NexStar™ 8

Introducing the New Celestron NexStar 8.

There is no substitute for size. With Celestron's legendary 8" optics, you can now see deeper into space with the same ease as with the innovative NexStar 5. With the touch of a button, the NexStar 8 will open doors to planets, galaxies and nebulae that you have never experienced in your lifetime. Exquisite design, pinpoint computer control and stability come together in one dynamic package.

Owning a NexStar 8 delivers a host of deluxe features including:

- **8" Schmidt-Cassegrain optics with Starbright coating group** – Large 8" aperture combines with Celestron's proprietary Starbright coatings to ensure maximum visual brightness and detail.
- **Cutting edge NexStar technology**
- **Automated Positioning Telescope** – Telescope easily finds thousands of preprogrammed astronomical objects.
- **Rigid metal fork arm and base construction** – For strength and durability.
- **Adjustable aluminum tripod** – Included standard in this complete system.
- **Photography capable** – Optional accessories allow you to take both planetary and terrestrial photos.

The NexStar 8's advanced computer features include:

- **Auto Align** – Enter your viewing location and time and you're ready to begin observing.
- **Control from your PC** – Communicate with the NexStar 8 via a built-in serial port.
- **Tour Function** – Selects the best and most spectacular objects for you to observe.
- **18,000+ Object Database** – The vast built-in database includes entries from the Messier, NGC and Caldwell catalogs as well as planets, selected SAO objects and 25 user-definable objects.
- **Easy-to-use Hand Control** – Numeric keypad with oversized buttons and red back-lit keypad.

See the NexStar 8 at your Celestron dealer today.

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HD TELESCOPES

HEAVY-DUTY TELESCOPES OFFER MORE VALUE THAN YOU MIGHT THINK!

HD SERIES TELESCOPES – two refractors – an 80mm (3.1") with a focal length of 900mm (f/11) and a 102mm (4.0") with a focal length of 1000mm (f/10); two Newtonians – a 114mm (4.5") with a focal length of 900mm (f/8) and a 150mm (6.0") with a focal length of 100mm (f/7).

All models come standard with a 6x30 finderscope and a premium 20mm Plössl 1¼" eyepiece.

OPTICS – all **HD** series telescopes have diffraction limited, premium optics manufactured to Celestron's uncompromising standards. The star images are classic textbook Airy disks. The Newtonians have multicoated optics and the refractors are fully multicoated to provide higher light transmission yielding bright, high contrast images.

The refractors have very good color correction. The 150mm Newtonian uses a state-of-the-art proprietary optical design incorporating an auxiliary correcting lens to reduce various aberrations, flatten the field and allow the tube length to be shortened – and it is superior to most fast parabolas.

MOUNT AND TRIPOD – the **HD** telescopes use the CG-4 German equatorial mount. It is a precision, heavy-duty mount which is upgraded and much better than the older polaris mounts.

The precision worm gears are extremely smooth in motion and the tracking accuracy is excellent. Optional motor drives make astrophotography easy and fun.

The tripod is a sturdy, adjustable height unit made of aluminium and it includes a heavy-duty accessory tray.

In addition, the 102mm refractor is offered with a **HD** altazimuth mount. This mount is easy to use and has slow motion controls (flexible cables) on both axes to allow for quick and easy pointing and tracking.

The superb optics with rigid mount and tripod of the **HD** telescopes allow you to enjoy awesome details of our moon such as craters, rills and mountain ranges; Saturn and its rings; Jupiter with its belts and moons; Mars, Venus and Mercury; deep-sky objects such as galaxies, nebulae, double stars and star clusters.

C114-HD
C102-HD
C150-HD
C102-AZ
C80-HD

For more detailed information on these telescopes, contact a Celestron dealer or Celestron.
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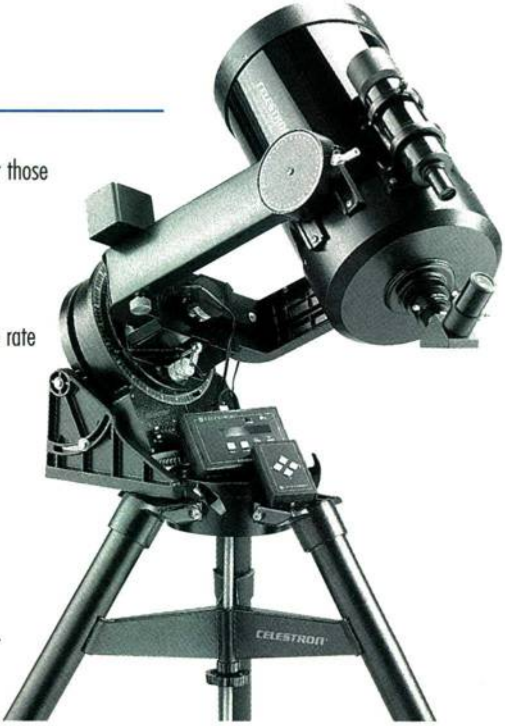
CELESTAR 8 TELESCOPES

CELESTAR 8

- Perfect for a first time astronomer.
- |An economical but full featured 8" (2032mm f/10) Schmidt-Cassegrain. A considerable amount of engineering work went into the design of the Celestar 8.
- No sacrifice was made in the optics. Celestron's carefully hand-figured system delivers diffraction-limited optics of unsurpassed quality. Starbright® coatings are standard.
- The energy efficient DC electronics are powered by a 9 volt alkaline battery for easy astronomy on the go.
- The totally cordless electronics have a built-in drive corrector which is activated when using the optional hand control. The R.A. motor's main tracking speed is an accurately regulated sidereal rate. The optional hand control allows for fast and slow override of R.A. tracking speed and ± operation of the optional DEC motor. A comment from the Sky & Telescope review – "the digital electronics delivered a near-perfect sidereal tracking rate."
- The Celestar 8 drive can operate in the Northern or Southern hemisphere from 0° to 90.°
- The unique Wedgpod is a combination tripod and wedge which is very stable.
- Made in the U.S.A.
- Standard accessories include: 6x30 Finderscope, Star Diagonal – 1¼" and a 25mm SMA Eyepiece – 1¼" (81x).
- Weight – 41 pounds.

CELESTAR 8 DELUXE

- For the more serious astronomer.
- This telescope utilizes the same superior optics and has all the features of the Celestar 8, but is enhanced, for those who prefer a premium version.
- This model has a heavier duty fork mount and drive base, with a precision worm gear drive system.
- Superior tracking accuracy is attained with this advanced drive system, which has four tracking rates and PEC (Periodic Error Correction).
- For the kind of versatility that makes observing a pleasure, the hand controller makes available a micro guide rate of .5x sidereal and a slew rate of 8x sidereal.
- The stepper motor drive electronics are cordless and operate on two 9 volt batteries.
- The Celestar 8 Deluxe has many features that are necessary for the more serious amateur astronomer, particularly if you're interested in astrophotography or CCD imaging with the PixCel or other CCD cameras.
- Fastar compatible for f/1.95 CCD imaging – deep sky images in 30 seconds or less!
- Made in the U.S.A.
- The standard accessories for this telescope include: Declination Motor, Car Battery Adapter, Hand Controller, Wedge and a Tripod with adjustable height that's exceptionally rigid and sturdy .
- Also standard is a large 9x50 Finderscope, Star Diagonal – 1¼" and a multi-coated 26mm Plossl Eyepiece – 1¼" (78X).
- Weight – 52 pounds.



ADVANCED ASTRO MASTER®

CELESTRON
Advanced Astro Master

The Celestar 8 Computerized and the Celestar 8 Deluxe Computerized telescopes are the same as the Celestar 8 and Celestar 8 Deluxe but with the addition of a factory installed and tested Advanced Astro Master.®

Its pointing system contains a data base of over 10,000 objects. Once aligned, it will guide you to any one of these objects. Included are the entire RNGC catalog, the Messier catalog, IC catalog (selected objects), major planets, over 241 interesting double and multiple stars and a user definable catalog of 25 objects. Operates on a standard 9V battery.

Contains an RS-232 serial interface to enable usage with programs like "The Sky"™ by Software Bisque.

For more detailed information on these telescopes, contact a Celestron dealer or Celestron. **Visit our Web site at www.celestron.com**

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ACCESSORIES BY CELESTRON

The Celestron Accessories here are universal – use with virtually any telescope.

PLÖSSL EYEPIECES

In a recent *Sky and Telescope* review, Celestron's 1¼" Plössl eyepieces were rated as **top ranking**, and found to outperform many similar, but more expensive eyepieces. An exceptional value! Celestron offers these premium eyepieces at affordable prices, yet they're among the best designed and corrected eyepieces available. They're **multicoated** for enhanced contrast and all models are threaded to accept Celestron colored eyepiece filters. **Focal length with field of view:** 6.3mm (52°), 7.5mm (52°), 10mm (52°), 12.5mm (52°), 17mm (52°), 20mm (52°), 26mm (50°), 32mm (52°), 40mm (46°).

ULTIMA® EYEPIECES

These are Celestron's top of the line 1¼" eyepieces. They feature long eye relief and a wide field, and each air-to-glass surface is **fully multicoated** to enhance contrast levels. These special eyepieces are computer designed to keep visual aberrations to an absolute minimum. Recently, *Sky and Telescope* reviewed Celestron's Ultima® eyepieces and rated them **best in their class**, with greater contrast and image sharpness than the competitive models of other manufacturers. The inside surfaces and edges of all lenses are blackened, to keep out reflected light. Threaded barrels accept Celestron thread-in filters. **Focal length with field of view:** 5mm (50°), 7.5mm (51°), 12.5mm (51°), 18mm (51°), 24mm (51°), 30mm (50°), 35mm (49°), 42mm (36°).

LV EYEPIECES

These Vixen brand 1¼" eyepieces (6 to 8 elements) are a new breed, using the rare earth glass lanthanum in one of their field lenses, for almost total freedom from any visual aberrations. All focal lengths have a comfortable 20mm of eye relief. Even when using the 2.5mm LV eyepiece on a telescope, you'll have eye relief of 20mm! These eyepieces also feature **fully multicoated** lenses for optical excellence. **Focal Length with field of view;** 2.5mm (45°), 4mm (45°), 5mm (45°), 6mm (45°), 9mm (50°), 10mm (50°), 12mm (50°), 15mm (50°), 20mm (50°), 25mm (50°).

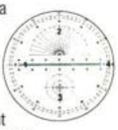
LV ZOOM EYEPIECE

This super premium 1¼" zoom eyepiece has a focal length of 8mm to 24mm. It is the finest zoom eyepiece for low to medium power observing. It's an excellent eyepiece that performs superbly, with **fully multicoated** surfaces. It offers an apparent field of 40° at 24mm and 60° at 8mm. Eye relief ranges from 15mm to 19mm.

CROSS HAIR EYEPIECE

This 1¼" eyepiece is of the Kellner design, with a focal length of 20mm. It's ideal for centering alignment stars when using digital setting circles or computerized telescopes. A useful all-around eyepiece for many applications, including terrestrial observing.

MICRO GUIDE EYEPIECE



This multifunction 1¼" guiding eyepiece features a laser-etched reticle with a built-in battery illuminator. The eyepiece is a **multicoated** 12.5mm Orthoscopic. Usage possibilities include: direct guiding on stars outside the center of the field of view; greatly improved off-axis guiding to capture much fainter, sharply focused guide stars without reducing limiting magnitude; and measuring position angles and separation of double stars. **Its finely etched micrometer scale** has gradations 50 microns apart and 15 microns wide. Included are: the eyepiece, built-in cordless illuminator with adjustable brightness control, batteries and instructions.

BARLOW LENSES

Celestron's premium quality .96" and 1¼" achromatic Barlow lenses are compact and lightweight. Both are under three inches long, with the 1¼" lens weighing in at 4 ounces and the .96" lens a mere 2 ounces! The clear aperture is 27mm on the 1¼" model, and 21mm on the .96" unit. The .96" Barlow is **fully multicoated** and the 1¼" lens is **multicoated**. The Ultima® Series Barlow (2x – 1¼") is an air-spaced, three element apochromatic design with a 27mm clear aperture. This lens features a very high quality, **fully multicoated** design. Amazingly compact and lightweight, it's just 5 ounces and 2¾" in length.

DIAGONALS

Celestron's Erect Image Diagonals are an Amici prism design. This design allows you to look into the telescope at a 45° angle, at images that are oriented properly, meaning the image is upright and correct from left to right. .96" to 1¼" models are available. Use of Celestron's hybrid .96" to 1¼" 45° Erect Image Diagonal on a telescope equipped with .96" eyepieces means greater versatility. This diagonal will allow you to use 1¼" eyepieces to obtain a larger field of view and better eye relief. A 90° 1¼" Erect Image Diagonal is available for those who prefer that angle. A 1¼" Star Diagonal (90°) is also available.

EYEPIECE FILTERS

Eyepiece filters are an invaluable aid in lunar and planetary observing. They reduce glare and light scattering, increase contrast through selective filtration, increase definition and resolution, reduce irradiation and lessen eye fatigue. Celestron's filters are made of high quality, solid plane parallel glass with excellent homogeneity. They're **antireflection coated** to prevent glaring and ghosting. All eyepiece filters are threaded to fit Celestron's, and most other manufacturer's, 1¼" eyepieces, and offer a full 26mm clear aperture. Filters available individually are: #12 Deep Yellow, #21 Orange, #25 Red, #58 Green, #80A Light Blue, #96 – 25% T, #96 – 13% T, Polarizing. In addition four different sets of four filters each are available.

1¼" POLARIZING FILTER SET

It's particularly useful for reducing glare while observing the moon, double stars, the planets and terrestrial subjects. You can vary the degree of transmission. By causing the amount of transmitted light to vary, the filters become, in effect, a continuously variable neutral density filter.

LPR FILTERS

Light Pollution Reduction (LPR) Filters are designed to selectively reduce the transmission of certain wavelengths of light, specifically those produced by artificial light. As a result, Celestron LPR Filters darken the background sky, making deep-sky observation of nebulae, star clusters and galaxies possible from urban areas. While blocking unwanted light, Celestron LPR Filters permit the transmission of more desirable wavelengths. This will improve your viewing of emission nebulae, both from urban and rural settings. They're also protected with a **broadband antireflection coating** to prevent ghosting and to improve contrast. They provide superior performance and contrast over competitive models. A 1¼" model threads into 1¼" eyepieces to work with virtually all telescopes.

MOON FILTERS

Celestron's Moon Filter threads into 1¼" eyepieces and aids in reducing the brightness of the moon and improving contrast, so greater detail can be observed on the lunar surface. The clear aperture is 21mm.

VIBRATION SUPPRESSION PADS

Telescope vibration is caused by windy conditions, an unsteady mount or tripod or even an accidental bump to the instrument, and results in reduced image quality. Celestron's set of three Vibration Suppression Pads **will reduce vibration time by almost 100%** and decrease vibration amplitude. The pads fit between the bottom of the tripod legs and the ground, a simple and functional solution to the problem of image disturbance.

NIGHT VISION FLASHLIGHT

Celestron's premium model for astronomy uses **two red LEDs** to preserve night vision better than red filters or other devices. Brightness is adjustable. Operates on a single 9 volt battery (included).

LENSPEN™

A superb new tool in optical lens cleaning technology. Perfect for cleaning binocular lenses, small aperture spotting scopes and telescopes, eyepieces, and other optical items. The LensPen™ comes with a handy retractable dust removal brush and a special non-liquid cleaning element, designed to never dry out. Safe and very easy to use.

SKY MAPS

Celestron Sky Maps are the ideal teaching guide for learning the night sky. You wouldn't set off on a road trip without a road map, and you don't need to try to navigate the night sky without a map either. Even if you already know your way around the major constellations, these maps can help you locate all kinds of fascinating objects. The front cover has a specially designed **luminous planisphere** that rotates to simulate the seasonal progression of celestial objects through the sky. When the planisphere is pre-exposed to light, star positions glow brightly against a dark background, mimicking actual constellations. More than a thousand stars and deep-sky objects are listed and charted.

PLANISPHERE

A simple and inexpensive tool for all levels of observers, from naked eye viewers to users of highly sophisticated telescopes. The Celestron Planisphere makes it easy to locate stars for observing and is a great planet finder as well. The Celestron Planisphere comes in three different models, to match the latitude from which you're observing: 20° to 40,° 30° to 50,° 40° to 60°.

TELESCOPE EQUATORIAL MOUNT–CG-3

A durable, rigid, German equatorial mount with a wooden tripod, offering both affordability and high quality. Designed as an excellent and inexpensive upgrade option when you're ready to move to a sturdier mount for your beginning telescope. R.A. and DEC setting circles, a latitude scale, slow motion controls and a handy accessory tray are included.

TELESCOPE EQUATORIAL MOUNT–CG-4

The CG-4 mount is a very rigid German equatorial mount. A counterweight, latitude scale, setting circles and slow motion controls on both axes are standard. The adjustable height aluminum, rigid tripod has **excellent damping characteristics** and a handy accessory tray. It is the same mount as used on Celestron HD telescopes and is a step up from the CG-3. Optional motor drives and a polar alignment finderscope are available.

TELESCOPE EQUATORIAL MOUNT–CG-5

The CG-5 EQ mount is the newest generation of Celestron's German mounts. Both axes of the equatorial mount have **precision worm gears** for extremely smooth motion. It is a step up from the CG-4. This **heavy-duty mount** delivers jitter-free images easily and the adjustable height aluminum, rigid tripod has excellent damping characteristics and a convenient accessory tray. Included are setting circles on both axes, slow-motion controls and latitude scale. An adjustable counterweight makes it easy to point, balance and use. An optional polar alignment scope for fast polar alignment as well as motor drives are available for easy tracking.

ALT-AZ PHOTO TRIPOD MOUNT

This heavy-duty mount is perfect for cameras with large telephoto lenses, and for spotting scopes and binoculars. If you already own a small telescope mount and are interested in one offering greater stability, the Alt-Az is an ideal upgrade. The adjustable wood tripod comes with two slow motion cables and is equipped with a ¼" x 20 photo head.

For more detailed information on these and other Celestron Accessories, contact a Celestron dealer or Celestron. Visit our Web site at www.celestron.com

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Eyepieces!

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12.4mm	101x	80
15mm	83x	80
20mm	63x	80
32mm	39x	100
40mm	31x	100
Super Wide- 67°		
13.8mm	91x	140
18mm	69x	150
24.5mm	51x	180
Ultra Wide- 84°		
6.7mm	187x	200
Zoom	52x-156x	220

TeleVue:

Plossl- 50°		
8 or 11mm		$84
15mm		84
20mm		97
32 or 40mm		114
PanOptic- 68°		
15mm	83x	210
19mm	66x	240
Radian- 60°		
6mm	208x	230
8mm	156x	230
10mm	125x	230
12mm	104x	230
Zoom	52x-156x	214

Meade ETX-90/EC ETX-125/EC

*Optional Autostar control provides LX200-type **GO TO** slewing to 14,000 objects!*

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We've got accessories for EVERY MODEL ETX!

Meade Accy's:	70/EC	90/EC	125/EC	Astro	
Autostar GO-TO #497	x	x	x		$150
Ac adapter #541	x	x	x		42
Case- hard #773	x				100
Case- hard #774		x			100
Case- hard #775			x		150
Case- soft #765		x		x	42
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Electric focuser #1244		x		x	Sale!
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NEAR-EARTH ASTEROID RENDEZVOUS

NEAR Arrives Right on Target

▶ NASA's Near-Earth Asteroid Rendezvous (NEAR) spacecraft slid into orbit around the asteroid 433 Eros on February 14, 2000. "Today is Valentine's Day for most people," said project scientist Andy Cheng immediately afterward. "But for me it is Christmas Eve, with the presents piled up under the tree, waiting to be opened."

Programmed to take its first orbital images across the length of Eros, NEAR demonstrated that it was almost precisely on target. The resulting mosaic held several surprises, including grooves, rims, layering, and a 170-foot-wide boulder at the bottom of a large crater.

Joseph Veverka, leader of NEAR's imaging team, says that in general, "the surface seems heavily cratered and old." Yet a feature on the asteroid's convex side, tentatively dubbed "the saddle" by scientists, had significantly fewer craters than the rest of the surface, indicating that more recent events had wiped that area clean.

Making the saddle even more puzzling is a series of layers or grooves running down one side and up the opposite wall. Such layering, which seems to run along Eros's length, "implies the possibility that Eros might have once been part of a larger body," notes Cheng. Several months of observations will be needed before scientists know for sure.

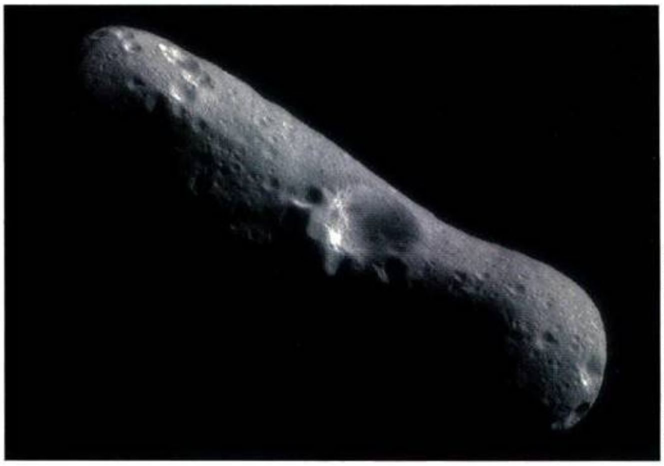
Other unexpected features include several bright spots that reflect approximately 25 percent more light than the surrounding terrain. "I have yet to hear anyone on the team hazard a guess as to what these are," says Cheng.

The house-sized boulder appears to have rolled into position. It, along with evidence of slumping along the crater walls, proves that even in a tiny gravitational field only one-thousandth as strong as Earth's, ordinary geological activity is possible.

The day before NEAR entered orbit, it took a full infrared scan of the asteroid's northern hemisphere. A preliminary analysis indicates that Eros is not homogeneous. "There are larger spectral variations at the asteroid's noses," notes Jim Bell of Cornell University, a member of the Multi-Spectral Imager and Near-Infrared Spectrometer team. When these data are compared with photos and laser topography scheduled for later in the year, scientists should be able to determine the asteroid's makeup and structure.

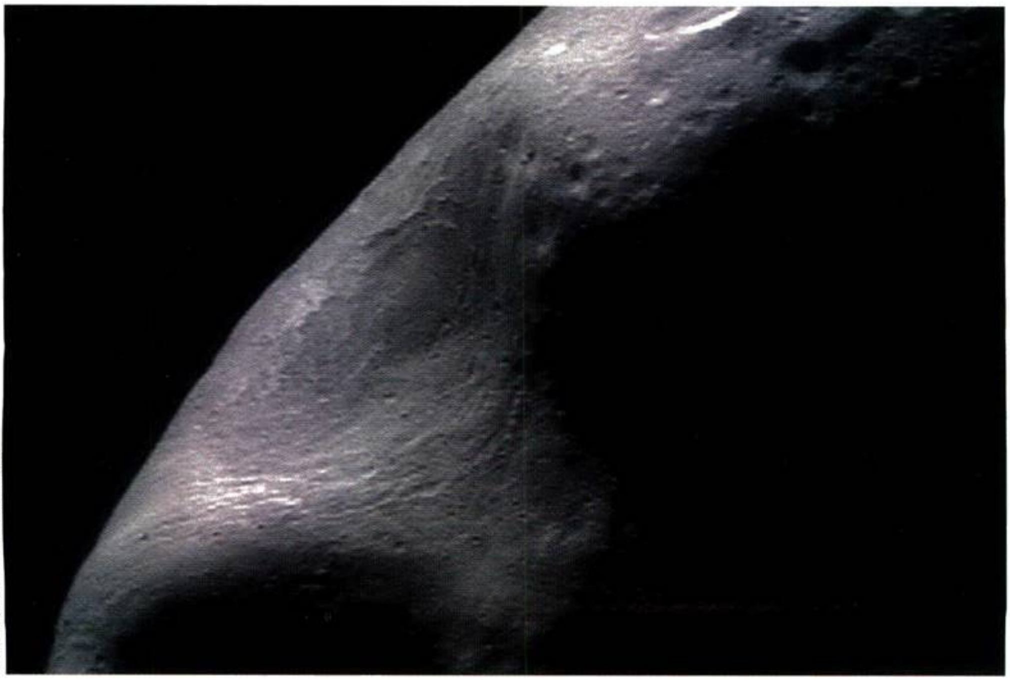
"It is all very tantalizing," Bell adds. "We are certainly eager to get more data."

— Robert Zimmerman



Johns Hopkins University and NASA

The first orbital mosaic of Eros reveals a 4-mile-wide crater with subtle variations in brightness that hint at layering. A house-sized boulder on the crater's floor appears to have rolled down the bowl-shaped wall.



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A large gouge called "the saddle" shows a paucity of craters, which implies it formed more recently than the rest of the surface.

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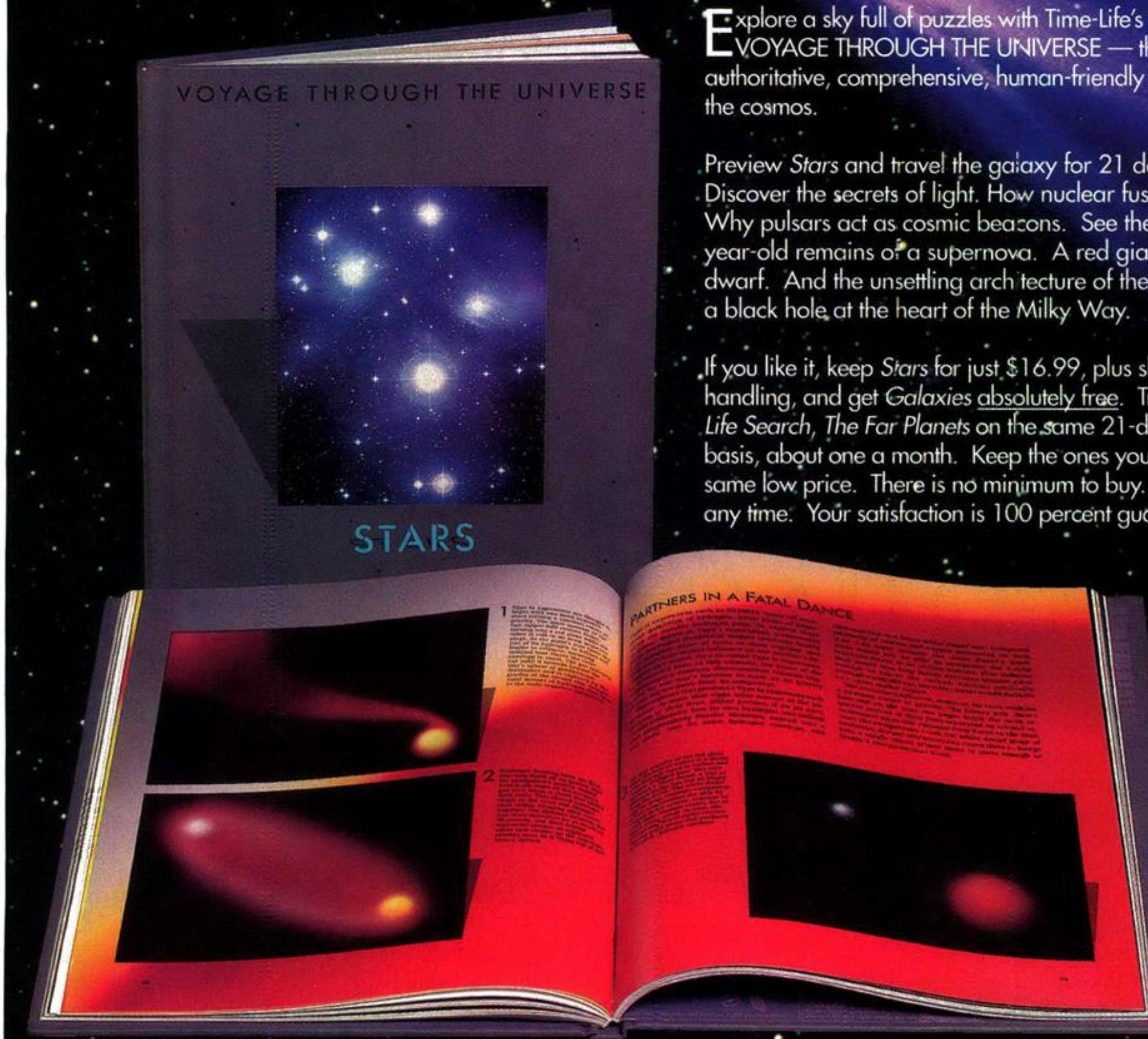

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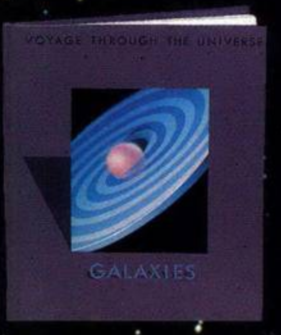

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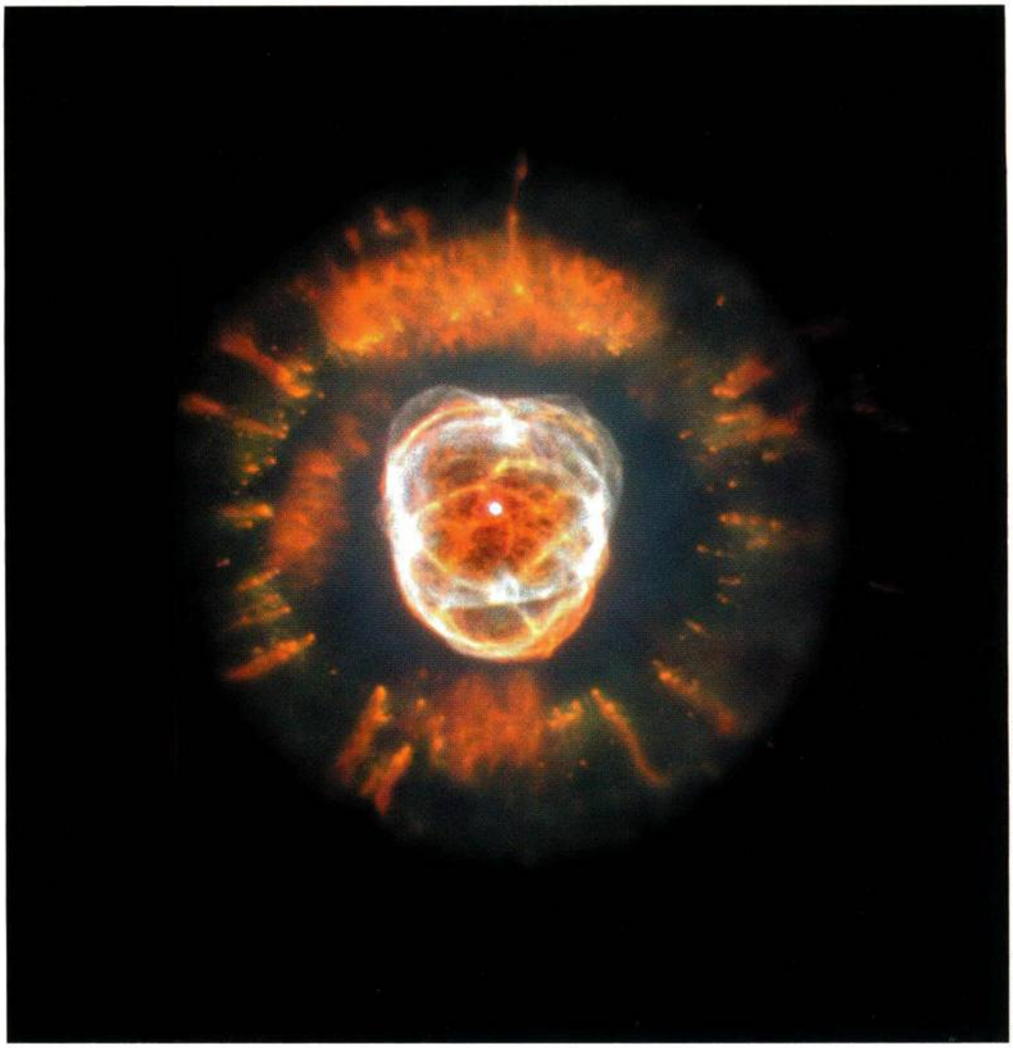
SPACE TELESCOPE

Hubble Is Better than New

The Hubble Space Telescope has reopened its eye on the cosmos, making a triumphant return to exploring the universe. The first images from the refurbished observatory show intricate detail in the gaseous tendrils of a planetary nebula and a chaotic mix of galaxies and luminous arcs created by the powerful gravity of a massive cluster.



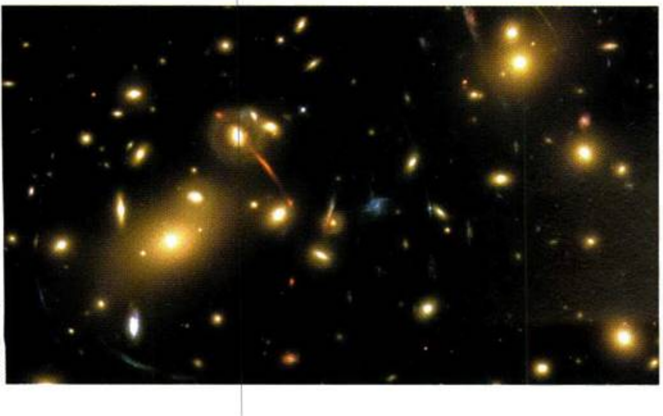
Hubble's first target after the recent servicing mission was the Eskimo Nebula, the glowing remains of a dying, sunlike star.

NASA, ESA, Andrew Fruchter (STScI), and the ERO team

The two images were taken between January 10 and 13 as part of the effort to recommission the orbiting telescope following the December 1999 space shuttle servicing call. Hubble had been out of action for nearly two months after a fourth gyroscope failed, leaving the telescope unable to point precisely. Shuttle astronauts replaced all six of the telescope's gyros and installed a new computer and solid-state recorder.

"Thanks to the great work by the astronauts, Hubble is better than new," says Ed Weiler, NASA's Associate Administrator for Space Science. No one who remembers the circumstances surrounding the discovery of the telescope's flawed primary mirror would dispute Weiler's assessment. But even more significant, the beefed-up electronics have Hubble operating at a higher level than it was before the critical gyroscope failed.

Two billion light-years away, the galaxy cluster Abell 2218 acts like a magnifying glass, creating luminous arcs from the light of even more-distant galaxies.



NASA, ESA, Andrew Fruchter (STScI), and the ERO team

The first target for the improved Hubble was the Eskimo Nebula (NGC 2392), a planetary nebula 5,000 light-years from Earth in Gemini. When viewed through ground-based telescopes, the Eskimo resembles a face surrounded by a fur parka, hence its nickname. The Hubble view shows that the "fur" resembles giant comets streaming away from the central star. Although no one knows for sure how these features originated, University of Maryland astronomer J. Patrick Harrington notes that "The clumps all seem to be at a similar distance from the star. That fact will be important in developing a theory of why the clumps formed in the first place."

The massive galaxy cluster Abell 2218 posed for Hubble's second portrait. Located some 2 billion light-years away in Draco, the cluster acts like an enormous zoom lens. Its gravity magnifies the light of

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more-distant galaxies, providing a probe of the distant universe. The color photo follows a black-and-white image of the same cluster taken by Hubble in 1994.

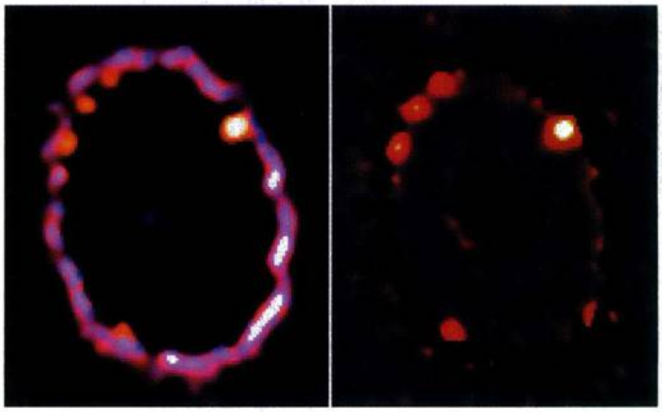
Richard Ellis of Caltech says that gravitational lensing preserves color, so the image will yield important insights into what these very distant and young galaxies are like. An unusual red object in the field particularly fascinates Andrew Fruchter, who led the team behind the early-release observations. "The color indicates that this object is either a rare, extremely cool dwarf star in our own Galaxy or one of the most distant objects ever viewed by Hubble that the cluster lensed into visibility." Learning the identity of this object awaits further observations. — Richard Talcott

SUPERNOVA 1987A

Supernova Ring Lights Up

▶ For astronomers observing Supernova 1987A in the Large Magellanic Cloud, the waiting game appears to be over. A gaseous ring 1.4 light-years wide surrounding the expanding cloud of debris shows signs of brightening, just as theorists predicted it would.

Although the ring's origin is not fully understood, astronomers believe it comprises material shed by the supernova's progenitor star some 20,000 years before it exploded. Soon after the ring was discovered in 1990, astronomers predicted that the supernova's blast wave would plow into it sometime between 1997 and 2006. The collision would compress and heat the material, causing it to light up.



The ring of material surrounding Supernova 1987A has started to brighten as the blast wave plows into it (left). When processed to emphasize detail, the February 2, 2000, Hubble image shows five bright knots of superheated gas (right). The bright hot spot at upper right first appeared in 1997. Peter Challis and Robert Kirshner (Harvard-Smithsonian Center for Astrophysics), Peter Garnavich (University of Notre Dame), and the SINS Collaboration

Hubble Space Telescope observations in 1997 showed a small, bright knot at the inner edge of the ring (see "Let the Fireworks Begin," May 1998). Theorists were confident the blast wave would soon smash into the entire ring, triggering many more hot spots.

Astronomers have continued to monitor SN1987A, patiently waiting for other hot spots to show up. Finally, in December 1999, a team using the 4-meter Blanco Telescope at the Cerro Tololo Interamerican Observatory in Chile observed a second one on the far side of the ring.

Subsequent Hubble observations in February not only confirmed this hot spot, they revealed a total of five, four of which are distributed along a 50° arc. The fifth hot spot lies far from the others.

Astronomers don't know why it took so long for additional hot spots to appear. But the wait appears to have been worth it. "This is evidence that the full scale interaction has finally begun," says Chun-Shing Jason Pun of NASA's Goddard Space Flight Center, a member of the team observing SN1987A with Hubble.

"During the next decade the ring will brighten optically by at least a factor of 100, possibly by 1,000, and by greater factors in x rays, ultraviolet, and infrared," adds Richard McCray of the University of Colorado. "The brightening will illuminate surrounding matter that has been invisible up to now. We may even be able to figure out what happened some 20,000 years before the supernova." — Robert Naeye

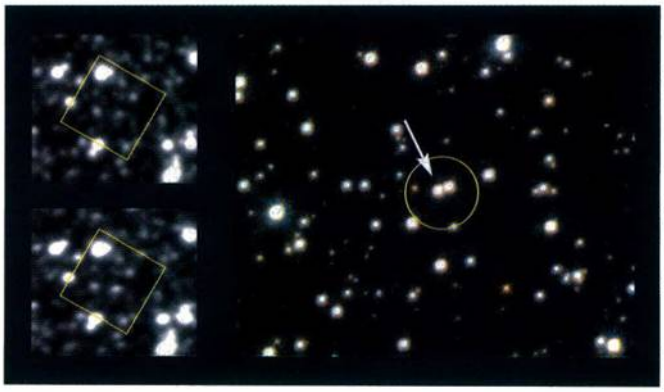
BLACK HOLES

Dark, Isolated, and Nearby

▶ For objects that give off no light of their own, black holes sure draw a lot of attention. Yet even jaded observers had to be impressed with the wealth of black hole news that came out of the January 2000 meeting of the American Astronomical Society in Atlanta, Georgia. Astronomers there announced that they had found both the nearest black hole and the first isolated black holes in the Milky Way Galaxy.

The nearest black hole lies 1,600 light-years from Earth and belongs to the binary system known as V4641 Sagittarii. This variable star has long been classified as an x-ray nova because it occasionally flares in x rays when material from a normal star

A black hole apparently passed in front of a star in the Milky Way's bulge starting in 1996, causing it to brighten over a span of 800 days (the left pair of images shows the brightening). A 1999 Hubble image of the lensed star (right) revealed its true brightness and allowed astronomers to estimate the black hole's mass at six times that of the sun.



David Bennett (University of Notre Dame) and NASA

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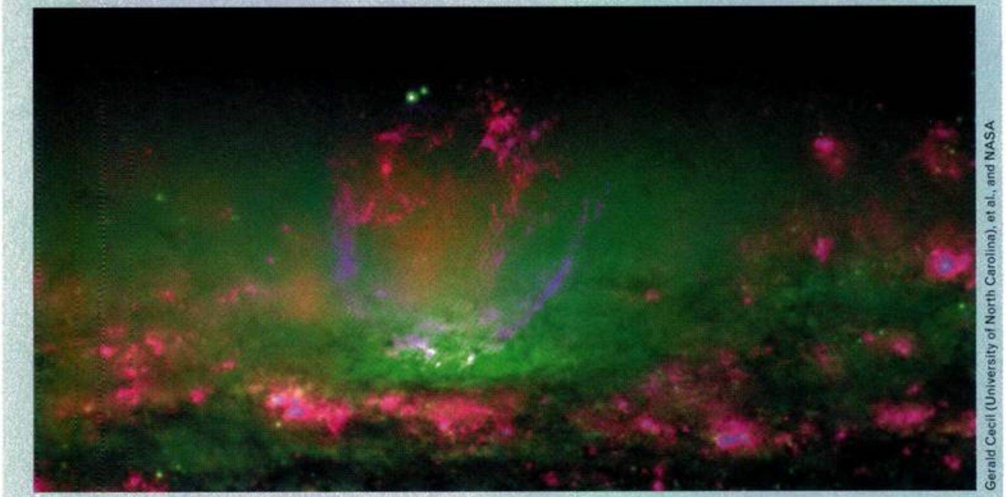


Gerald Cecil (University of North Carolina), et al., and NASA

PACKING THE WALLOP OF 2,000 SUPERNOVAE, a gigantic "superbubble" rises above the disk of NGC 3079, a barred spiral galaxy in Ursa Major some 50 million light-years from Earth. A team of astronomers led by Gerald Cecil of the University of North Carolina at Chapel Hill used Hubble's Wide Field and Planetary Camera 2 to capture a false-color image of the galaxy's nucleus and resolve the bubble's shell into dozens of bright filaments. The bubble began inflating about a million years ago and currently spans 3,500 light-years, requiring a galactic superwind with an energy equivalent to that of 2,000 supernovae exploding at the center of the galaxy. The research team thinks that the powerful wind that inflated the superbubble came from either an intense burst of star formation or the hot accretion disk surrounding a supermassive black hole.

falls onto its compact companion. Yet its true identity wasn't revealed until it erupted suddenly on September 15, 1999.

The drama started when Australian amateur astronomer Ron Stubbings noticed the star shining six times brighter than it had been the night before. An e-mail announcement sent worldwide found its way to Donald Smith of MIT, who observes with the Rossi X-ray Timing Explorer satellite. The satellite showed V4641 Sgr was flooding our neighborhood with x rays, making it the brightest source in the sky after the sun.

But that wasn't all — V4641 Sgr was behaving like no other x-ray nova ever seen. "It was turning on and off so fast that it seems to represent a new subclass of x-ray novae," says Smith. All told, four separate and very brief x-ray outbursts occurred.

When Robert Hjellming of the National Radio Astronomy Observatory targeted V4641 Sgr with the Very Large Array, he discovered twin jets shooting from the system at slightly more than 90 percent the speed of light. Only three other systems in our Galaxy eject material at such speeds, earning them the nickname microquasars. Astronomers are convinced that microquasars harbor black holes because their intense gravity is the only way to generate so much power. And V4641 Sgr lies closer to Earth than any other such object, making it the closest black hole known.

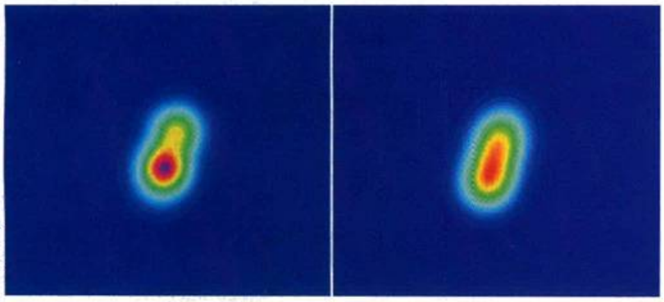
V4641 Sgr, like every other suspected black hole in our Galaxy, was discovered by the radiation emitted as it eats material from its surroundings. But David Bennett of the University of Notre Dame and his colleagues tried a different approach.

A black hole's powerful gravity acts like a lens, bending light from background stars and making them appear brighter. Bennett's team looked at more than 300 such microlensing events detected by the Massive Compact Halo Object collaboration and found two long events, one lasting 800 days and the other 500 days.

The long durations suggest a high mass for the lensing objects, and follow-up observations of the background stars from the ground and with Hubble helped pin down the masses of the lenses to about six times that of the sun. Yet the lensing objects are not seen. Any normal star that big would appear bright, and neither a white dwarf nor neutron star can have that much mass — so the lenses must be black holes.

"These results suggest that black holes are common," says Bennett, "and that many massive but normal stars may end their lives as black holes instead of neutron stars." If this proves true, isolated black holes could be a source of much of our Galaxy's dark matter. — R. T.

Radio emission from the microquasar V4641 Sgr, which harbors the nearest black hole to Earth, changed markedly in just 30 minutes last September. Initially (left) the emission peaks near the binary star's position, but half an hour later (right) much of it has spread along a jet moving at 90 percent the speed of light.



R. Hjellming, NRAO, and AURA

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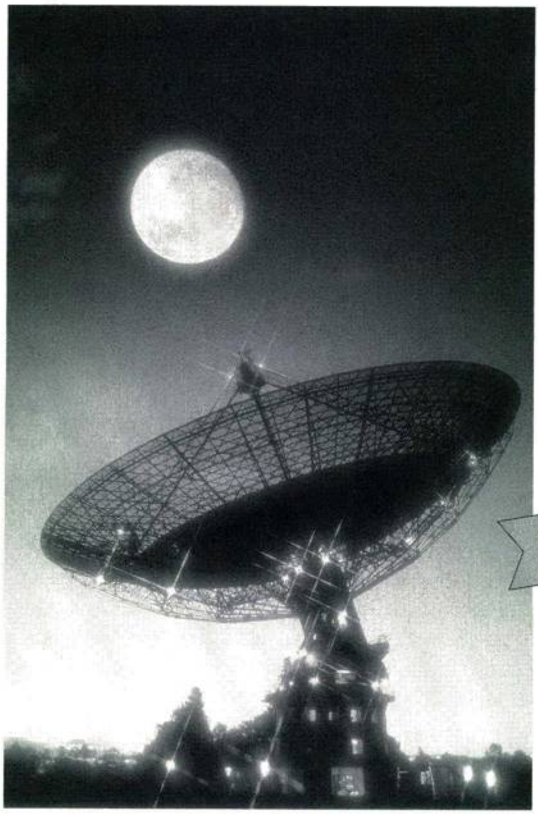

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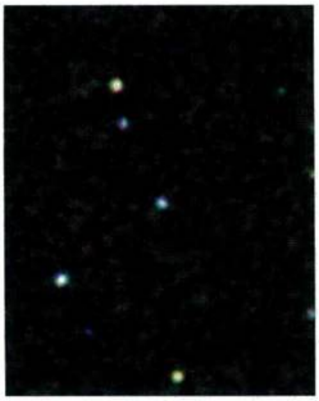

University of Massachusetts and Caltech/IPAC

The coolest brown dwarf ever found, Gliese 570D, lies at the center of this 2MASS image.

BROWN DWARFS

Too Cool to Be a Star

► Although it may be hotter than a summer barbecue, a recently discovered object turns out to be cooler than any star or failed star ever seen. The object is a brown dwarf located near the triple star system Gliese 570ABC, only 19 light-years from Earth in Libra.

Brown dwarfs are often called failed stars because they form from collapsing gas clouds as stars do, but they aren't massive enough to sustain the nuclear reactions that power stars.

Caltech astronomers Adam Burgasser and Davy Kirkpatrick found the brown dwarf in an image taken in May 1998 by the Two Micron All Sky Survey (2MASS), an ongoing survey of the sky at infrared wavelengths run by the University of Massachusetts at Amherst and Caltech's Infrared Processing and Analysis Center.

The brown dwarf showed up as a faint object near Gliese 570ABC. A 2MASS image taken 14 months later showed that the faint object moved with the rest of the system, confirming that it lies at the same distance.

The brown dwarf, now known as Gliese 570D, is so cool that it doesn't even give off enough visible light to show up in the images of the Palomar Observatory Sky Survey. A spectrum of Gliese 570D taken by Burgasser with the 4-meter telescope at the Cerro Tololo Inter-american Observatory revealed methane, a molecule that breaks apart in the hotter atmospheres of stars.

Based on an analysis of the spectrum, Burgasser and Kirkpatrick estimate the object's temperature to be about 750 kelvins (900° F), which is about 200 kelvins cooler than the previous record holder, the brown dwarf Gliese 229B. Gliese 570D is only about 1.5 times hotter than the maximum setting on a typical kitchen oven.

Gliese 570D probably orbits the entire triple star system. If so, it orbits at about 1,500 times the Earth-sun distance and takes roughly 40,000 years to complete one orbit. Only a few brown dwarfs have been found orbiting normal stars, and all of them orbit at relatively large distances. "It could be that these little pip-squeak brown dwarfs get ejected easily from the inner environs of more massive stars and get thrown into much bigger orbits," says Kirkpatrick.

Gliese 570D is about the same diameter as Jupiter but contains 50 times more mass. "The dividing line between planets and stars was once obvious," says Burgasser, "but we are now finding objects that really blur that distinction." — R. N.

New Martian Meteorite Found

Cleaning up rat nests and rodent droppings may not sound like fun, but it can prove scientifically interesting. At least that's what Californian Bob Verish learned when he cleaned out his rock collection last October. Two rocks in particular — weighing 453 and 245 grams (16 and 9 ounces) and collected some 20 years ago in the Mojave Desert — caught his eye. Verish, who began collecting meteorites about five years ago, noticed the dark crust on the rocks and suspected they might be meteorites. He took samples of each to UCLA, where researchers verified they were meteorites and noted their strong similarity to a martian meteorite discovered in 1994 in Antarctica. Further analysis showed the rocks' composition matched that of the Red Planet, confirming that the rocks originated on Mars. This raises to 14 the number of known martian meteorites.

Ron Baalke

This 1-pound rock came to the Mojave Desert from Mars.

Does Anybody Really Know What Time It Is?

There's an old joke that says a man with one watch always knows what time it is while a man with two watches is never sure. Now, thanks to the new cesium atomic clock at the National Institute of Standards and Technology in Boulder, Colorado, anyone in the United States can be sure that his or her time is accurate to one second in nearly 20 million years. Known as NIST F–1, the clock began its role as the nation's primary standard in December, when it made its first contribution to an international pool of atomic clocks used to define Coordinated Universal Time. Approximately three times more accurate than its predecessor, NIST F–1 shares the distinction of being the world's most accurate clock with a similar device in Paris.

Possible Companions for Uranus and Neptune

A rare class of object that appears superficially similar to traditional moons may dwell in the outer solar system. These "quasi-satellites" don't orbit a planet but instead orbit the sun in the vicinity of a planet, existing in what's called a 1:1 mean-motion resonance. Paul Wiegert and Kim Innanen of York University in Toronto and Seppo Mikkola of Tuorla Observatory in Finland have investigated the stability of possible quasi-satellites around the gas-giant planets. They find that those around Uranus and Neptune can survive for the 4.5-billion-year age of the solar system and conclude that a primordial population of such objects may still exist. However, any around Jupiter would become unstable in 10 million years and those around Saturn in less than 100,000 years.

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Speed Matters

How do you learn about events that are over almost as soon as they begin? Astronomers are finding a way.

by Robert Zimmerman

ON JANUARY 23, 1999, the gamma-ray-burst detector on the orbiting Compton Gamma Ray Observatory began registering a burst of energy. In four seconds a message had gone out by e-mail to more than 50 astronomers and observatories worldwide, and within 22 seconds, a specially designed robotic telescope standing ready in Los Alamos, New Mexico, had swung to the spot where that gamma-ray burst was thought to come.

This telescope, the Robotic Optical Transient Search Experiment, or ROTSE for short, had been built by astronomers from the University of Michigan for just this moment. Snapping a picture every five seconds, its camera captured the first visible-light images of the rise and fall of a gamma-ray burst, its brightness zooming from invisible to 9th magnitude in five seconds and then fading away over the next ten minutes.

ROTSE's stupendous achievement of catching this ephemeral burst of light illustrates nicely how the science of astronomy is changing. From gamma-ray bursts to x-ray transients to supernovae, the explosive nature of the celestial sky has forced astronomers to develop techniques that allow them to get to places in the blink of an eye.

Astronomy has also gone global. Scientists from every continent now work together with a dazzling array of instruments scattered across — and under — Earth's surface as well as dispersed throughout the solar system. Some of these devices are even headed into interstellar space.

What makes this revolution even more appealing is that the growing sophistication and lower cost of computers is making possible the direct participation by amateur astronomers. In fact, anyone reading this article with the gumption, commitment, and not unreasonable cash resources can get involved in the hands-on discovery of new phenomena. ROTSE, for example, was built partly using equipment assembled from commercial 35mm camera lenses as well as parts culled from the amateur astronomy market.

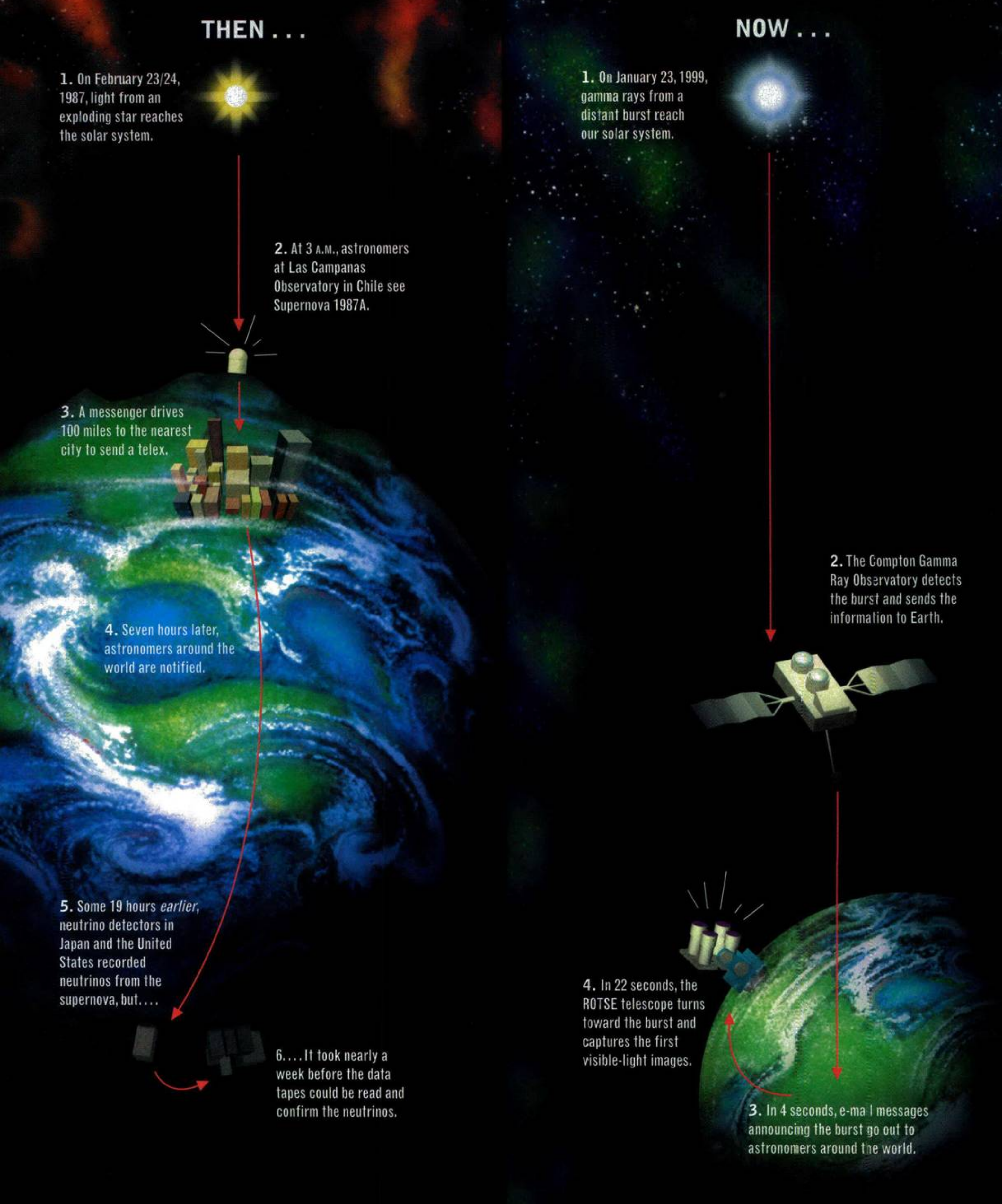
In Olden Times . . .

To understand how much the speed and range of astronomy has changed in just the last 13 years, we need only go back to February 23/24, 1987. On that night Supernova 1987A exploded in the Large Magellanic Cloud, becoming the first supernova in more than three hundred years to be visible to the naked eye.

Astronomer Ian Shelton first identified the supernova at around 3 A.M. He and the other astronomers at the Las Campanas Observatory in the Andes Mountains of Chile then tried to notify the Central Bureau for Astronomical Telegrams in Cambridge, Massachusetts. Run by the International Astronomical Union and under the leadership of Brian Marsden, the Central Bureau

A gamma-ray burst suddenly and brilliantly illuminates the spiral arm of a young galaxy. Illustration by Adolf Schaller

Faster than a Speeding Bullet



THEN . . .

1. On February 23/24, 1987, light from an exploding star reaches the solar system.

2. At 3 A.M., astronomers at Las Campanas Observatory in Chile see Supernova 1987A.

3. A messenger drives 100 miles to the nearest city to send a telex.

4. Seven hours later, astronomers around the world are notified.

5. Some 19 hours *earlier*, neutrino detectors in Japan and the United States recorded neutrinos from the supernova, but. . . .

6. . . . It took nearly a week before the data tapes could be read and confirm the neutrinos.

NOW . . .

1. On January 23, 1999, gamma rays from a distant burst reach our solar system.

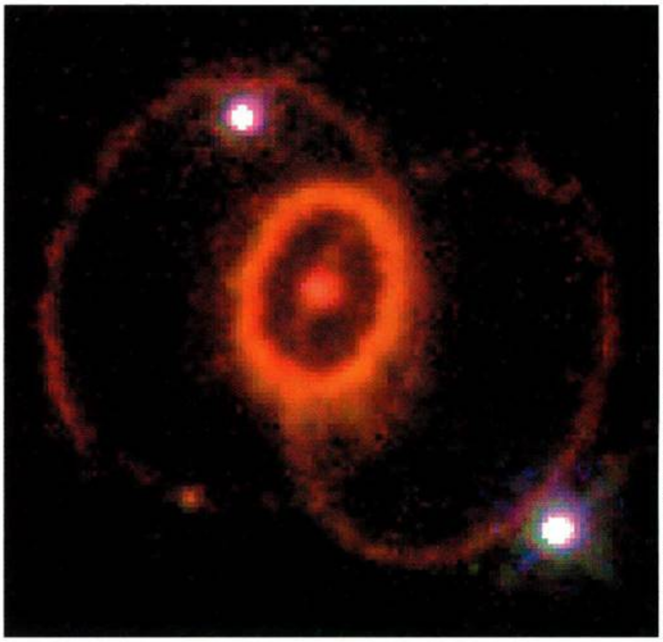
2. The Compton Gamma Ray Observatory detects the burst and sends the information to Earth.

3. In 4 seconds, e-mail messages announcing the burst go out to astronomers around the world.

4. In 22 seconds, the ROTSE telescope turns toward the burst and captures the first visible-light images.

Hubble Heritage Team (AURA/STScI/NASA)

A massive star exploded in the Large Magellanic Cloud in 1987, at the center of three gaseous rings expelled by its progenitor star.



Christopher Burrows (ESA/STScI) and NASA

The outrushing debris from Supernova 1987A was halfway to the inner ring in this 1994 image; the collision began in earnest early this year.

acts as a clearinghouse for all discoveries. Astronomers, both professional and amateur, notify the Bureau of their discoveries and the Bureau then notifies the rest of the world.

In 1987 the Bureau was just beginning to computerize its operation. At the time, notices were sent out first with a short 15-word telegram, followed by a circular sent by regular mail. Subscribers also had the option of logging onto a computer bulletin board to check for recent announcements.

To make his discovery official, however, Shelton first had to let Marsden know about it. Phone calls to the Bureau (no one involved at the time had either e-mail or laptops) went unanswered. In Cambridge, it was the wee hours of the morning. "We don't have the resources to have someone here all the time," Brian Marsden laments.

Getting desperate, the astronomers in Chile finally had someone drive by car down the mountain and 100 miles to the nearest city. There a telex was sent, arriving at the Bureau about seven hours after Shelton first detected the supernova.

With telegrams now arriving on astronomers' desks worldwide, other more exotic telescopes began swinging into action, though that action sometimes took days to complete. A pair of neutrino detectors, one in Japan and the other in the United States, took almost a week to prove that a burst of neutrinos from the supernova had swept past Earth around 7:35 A.M. on February 23, 19 hours before the arrival of the photons seen by Shelton. The neutrinos arrived first because they were able to escape the center of the exploding star instantly. The photons weren't released until the shock wave from the star's collapsing core broke through the surface.

At Japan's Kamiokande detector, refitted only a few months earlier to measure just this type of outburst, the data tapes had to be shipped by bus from the mountain where the underground telescope was located to Tokyo where a computer could read the results. Though the supernova occurred on Tuesday morning, Kamiokande's scientists learned that their telescope had seen it four days later, on Saturday.

In space, only two orbiting telescopes were in operation, the Japanese x-ray satellite Ginga and the United States/European International Ultraviolet Explorer (IUE). With IUE, astronomer Robert Kirshner of Harvard University had a standing proposal to look at any erupting supernova. When he found out about SN1987A, not by a telegram from the Central Bureau but "by a whispering campaign," as he remembers, he immediately scrambled to get IUE pointed in the right direction. One day later, he obtained the first ultraviolet observations. "We did miss a chance to see the earlier stages of a supernova," he notes, "including the ultraviolet flash and the fastest moving stuff."

Ginga also began looking at the supernova within hours of the announcement, but no x-ray emission was observed for several months. When it was detected in August, the timing helped prove the nature of the supernova's expanding shell of gas — as the shell expands, it finally thins out enough so that the x rays from the explosion can leak out.

Getting There Fast

Such was the pace of astronomy a mere 13 years ago. It took hours to spread the news and days to get the available telescopes on target. Yet for supernovae, this leisurely pace is not a major hindrance. From the time the first wave of neutrinos sweeps past Earth to the arrival of the first optical light, several hours can pass. Even then, the event will go on for months and even years afterward.

Gamma-ray bursts, however, leave no time for introspection. These fleeting and mysterious eruptions of gamma rays, discovered in the 1960s, are the most elusive of all sky events: They can occur anywhere on the sky and at any time. Most last somewhere between five and thirty seconds (though a few have lasted as long as fifteen minutes). Because there is no way to predict where and when a burst will occur, standard optical telescopes have no way to catch them in action. By the time most telescopes swing their eye to the burst's location, it is gone. So for nearly 30 years, no astronomer had seen a gamma-ray burst in any radiation other than gamma rays — a shortcoming that left their distance, energy, and cause completely unknown.

Much of the innovation in astronomy in the last decade has been driven by the effort to solve this mystery. First, several quick-alert networks were created. The Inter-Planetary Network, which began in 1974 with American and Soviet satellites, was set up under the leadership of Kevin Hurley of the University of California at Berkeley. Today it uses detectors on several spacecraft in Earth orbit and interplanetary space to triangulate the sky position of any burst of gamma rays or x rays. The Network paid dividends in December 1999, when it located a burst accurately enough to allow astronomers to observe it at other wavelengths.

But that wasn't the first time a gamma-ray burst had been seen in radiation other than gamma rays. The Italian/Dutch BeppoSax satellite detected a burst in February 1997 and within eight hours used high-resolution x-ray cameras to pinpoint it. The Hubble Space Telescope caught the optical afterglow several weeks later. For the first time, astronomers learned that a burst occurred in a distant galaxy, proving that it lay several billion light-years away and was therefore one of the most powerful explosions in the universe.

Faster but less accurate than the Inter-Planetary Network or BeppoSax is the e-mail gamma-ray alert network called the Global Coordinate Network (GCN). Linked to the Burst and Transient Source Experiment on the orbiting Compton Gamma Ray Observatory, GCN sends out an e-mail notice to around 75 astronomers within four seconds after the detectors sense the arrival of a gamma-ray burst. The notice gives a rough estimate of the burst's location, no less than five degrees across, from which other telescopes can attempt to find the burst in other wavelengths.

To use the fast but rough data from GCN, the makers of ROTSE — as well as a second fast response telescope called LOTIS (for Livermore Optical Transient Imaging System) in California — had to conceive a telescope very different from traditional instruments. Both telescopes grew out of a Strategic Defense Initiative project, and both use some of the same equipment. Unlike most new telescopes, the goal of ROTSE and LOTIS was not greater resolution and an ability to see farther and deeper, but an ability to see a larger area of the sky more quickly. ROTSE's field of view is an incredible 16 by 16 degrees, while LOTIS's spans 17 by 17 degrees. Neither telescope can see objects fainter than 15th magnitude, but when triggered by an alert both can be re-aimed automatically to photograph any part of the sky in less than ten seconds.

In the case of GRB 990123, LOTIS failed to see the burst only because it was raining in California at the time. The weather in New Mexico was better and ROTSE managed to capture the optical image. The incredibly fast rise and fall of the optical light indicated that the explosion was asymmetrical and that we might have been looking down a jet beam.

A Global Village

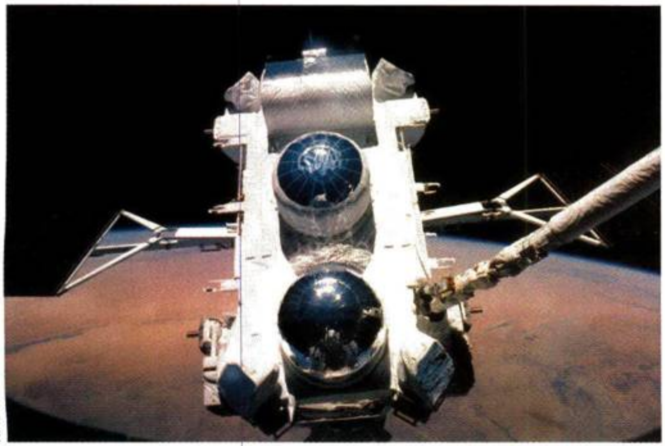
Modern astronomy requires more than just speed, however. It also requires a wide range of telescopes working at as many wavelengths as possible. Celestial phenomena, including other transient events besides gamma-ray bursts, emit radiation across the entire electromagnetic spectrum, with each type of radiation providing different information about the nature of the phenomenon.

To gather this information, astronomers now have a huge selection of telescopes at their command, far more than when SN1987A exploded. Telescopes on the ground and in space peer outward in every wavelength from low-energy radio to powerful gamma rays. For example, the Compton Gamma Ray Observatory and the BeppoSax satellite quickly augmented the optical data from ROTSE with x-ray and gamma-ray observations, while the Inter-Planetary Network pinpointed the burst's location. Hubble also snapped a picture, revealing the burst's host galaxy.

On the ground, the 60-inch telescope at Palomar Observatory, the 394-inch (10-meter) Keck II Telescope on Mauna Kea, and the 102-inch (2.6-meter) Nordic Optical Telescope in the Canary Islands all helped pin down the object's redshift and approximate distance. Meanwhile the Very Large Array radio telescope in New Mexico detected a short radio burst, suggesting that both the ROTSE optical burst and the radio emission were caused when the shock wave from the burst's fireball — after colliding with the interstellar medium — bounced back and crashed against itself.

This global astronomical village is enhanced by the use of the world wide web. For instance, in December 1995 a previously unknown object near the center of the Galaxy suddenly began sending out violent and random x-ray bursts. While phone calls, e-mail, and electronic bulletins from the Central Bureau disseminated new data worldwide with some speed, none of these methods was fast enough to coordinate the work of almost a hundred researchers using dozens of different telescopes both on and off Earth.

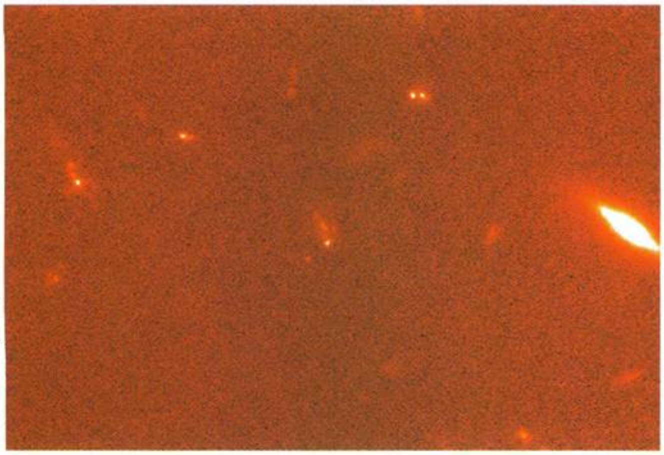
The Compton Gamma Ray Observatory (seen here being deployed from the space shuttle) first detected the January 1999 gamma-ray burst.



NASA

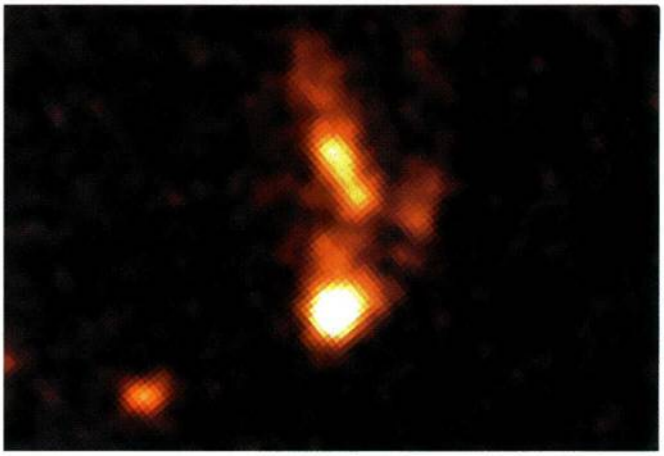
Twenty-two seconds after Compton detected the burst, the ROTSE telescope had swung to its position and captured it in visible light.

ROTSE Collaboration



Andrew Fruchter (STScI) and NASA

The gamma-ray burst of January 23, 1999, originated in the faint, distant, and young galaxy seen at the center of this Hubble image.



The Caltech GRB Team/STScI

A close-up shows the fingerlike filaments of the host galaxy, apparently a starburst galaxy, extending above the white blob of the burst.

To solve the problem and establish a precedent now used routinely, astrophysicist Robert Rutledge created a web page. "It was obvious that to reach as many researchers as possible, a web page was the most efficient way," Rutledge says. "The number of people one reaches is without limit." The page he constructed for GRO J1744–28, as the strange x-ray burster was dubbed, became the clearinghouse for information used by scientists from almost every continent.

The Internet has also made easier the development of additional quick-alert networks. The SuperNova Early Warning System (SNEWS) uses a simple software package in conjunction with already existing neutrino detectors. In 1987 optical astronomers told neutrino astronomers that their detectors might have seen a burst of neutrinos from the supernova. SNEWS hopes that in the future it will be the neutrino astronomers who will announce, in advance, the pending arrival of the light of a supernova.

Currently in test mode, when fully operational, SNEWS will link neutrino detectors in Japan, Italy, Antarctica, and Canada. When any two of these detectors register a simultaneous burst of neutrinos, SNEWS will automatically send out an electronic notice within ten seconds to the entire astronomical community, including both amateurs and professionals. Although SNEWS might not be able to triangulate the supernova's location in the sky precisely, for several hours every astronomer in the world will be on the edge of his seat, staring upward, knowing that any minute he will get his first glimpse of the violent death of a star.

Amateurs Join the Fray

Remarkably, the greater sophistication and grander scale of modern astronomy is actually increasing the chances that amateur astronomers can get involved in real discoveries. With SNEWS, anyone who is part of the International Supernova Network, an organization of amateur supernova observers, will receive the announcement. If they get to their telescopes fast enough, they will have the chance of savoring an experience even better than Ian Shelton's in 1987 — viewing a supernova *as it happens*. Moreover, GCN recently began setting up procedures for including amateurs in its network. Interested members of the American Association of Variable Star Observers will be able to get GCN alerts, either by e-mail or pager, allowing them the chance to catch a gamma-ray burst afterglow with their telescopes.

In some ways amateurs are better able to observe such events. Astrophysicist Hurley points out that, "Not many professionals will be able to get their big telescopes on these events as quickly as an amateur would."

Even more intriguing is the possibility that determined amateurs could build their own ROTSE clones. ROTSE's mount, camera, and lens are all commercially available. The computers are nothing more than 200 MHz Pentiums, outdated home PCs that can be had on the used computer market for spare change. And the enclosure that protects the telescope from bad weather was a Vietnam-era electronics shed found in a junkyard and purchased for $250.

The software, probably the most important part of ROTSE's package, is also available. "Though we couldn't provide any support, and it would take a great deal of work to get the software running, we would gladly provide it free to any amateur astronomer who wants it," says University of Michigan astrophysicist Robert Kehoe of the ROTSE project.

For an amateur to develop a telescope as fast and reliable as ROTSE would require a thoroughness and determination greater than going to a star party to skygaze. And building an exact ROTSE clone would take in excess of many thousands of dollars. Yet, as astronomer Craig Wheeler of the University of Texas recently noted, "The only difference between a professional and an amateur astronomer is that the professional spends someone else's money." Some amateurs have spent thousands outfitting private observatories, and a slightly scaled down version working in conjunction with GCN would certainly be conceivable.

Should an amateur take up the challenge and build a ROTSE clone, the opportunities for research will extend far beyond gamma-ray bursts. Such quick-look wide-field telescopes are ideal for finding comets and asteroids. They can also be used to discover or monitor many types of variable stars. And such a telescope might even find things as unanticipated as gamma-ray bursts were in the 1960s. As Kehoe remarks, "There have got to be objects out there varying on the timescale of seconds that nobody even knows about." ■

Robert Zimmerman is a regular contributor who wrote "Scoping out the Monster Star" in the February issue. His two most recent books, Genesis, The Story of Apollo 8, *and* A Chronological Encyclopedia of Discoveries in Space, *are both now available.*

Meet the
COSMIC GAMBLER

What do spiral galaxies, Saturn's rings, and forming stars have in common? They have all drawn the attention of Frank Shu.

by Ray Jayawardhana

FRANK SHU WENT TO FIRST GRADE THREE TIMES. Not that he needed remedial help. In fact, at the tender age of four, he tested into the third grade. But his mother decided it would be best for him to enter first grade with his peers. Within a year, the family moved twice, from mainland China to Taiwan and then to the United States. And young Shu attended first grade in each of those countries. "I know that material extremely well," chuckles Shu.

Perhaps it wasn't such a bad way to start a life in academics. Today, Shu is based at the University of California at Berkeley and is university professor of the nine campuses of the University of California. He is widely regarded as one of the world's foremost experts on star formation, having created detailed physical models of how stars are born that explain the observations.

University of California astronomer Frank Shu feels at home whether he's standing at the pool table, sitting down for a game of poker, or unraveling the secrets of how stars are born. Raleigh Souther

"His influence on our understanding of star formation is unmatched by any other theorist," says Charles Lada of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts.

Shu's influence is felt in many other ways. He is a past president of the American Astronomical Society (AAS), the major organization of professional astronomers in North America. Shu has also written several widely used textbooks and produced an impressive list of Ph.D. students who have themselves become prominent astronomers. In recent years, he has helped establish the Institute for Astronomy and Astrophysics in Taiwan.

COMING TO AMERICA

Shu was born in Kunming, China, in 1943. He was barely two months old when his father left for the United States to attend graduate school at Brown University. In 1948, with Mao's Communists on the verge of taking over China, Shu's father decided not to return home. Instead, he made arrangements for his wife and three children to move to Taiwan. In less than a year, they joined him in the United States. Shu's father, who was an applied mathematician, taught at Purdue and several other midwestern universities.

After skipping the final year of high school in Indiana, Frank Shu entered the Massachusetts Institute of Technology at age 16. Through his father's influence, he had always been interested in mathematics and science, and it was only natural for Shu to major in physics. "I was not your model student," he recalls. "Fortunately, I was able to learn quickly, to cram." His interest in astronomy owes its origins to C. C. Lin, a theorist who was on the MIT faculty. "Until then, I'd never thought of doing astronomy," Shu confesses.

"I was not your model student."

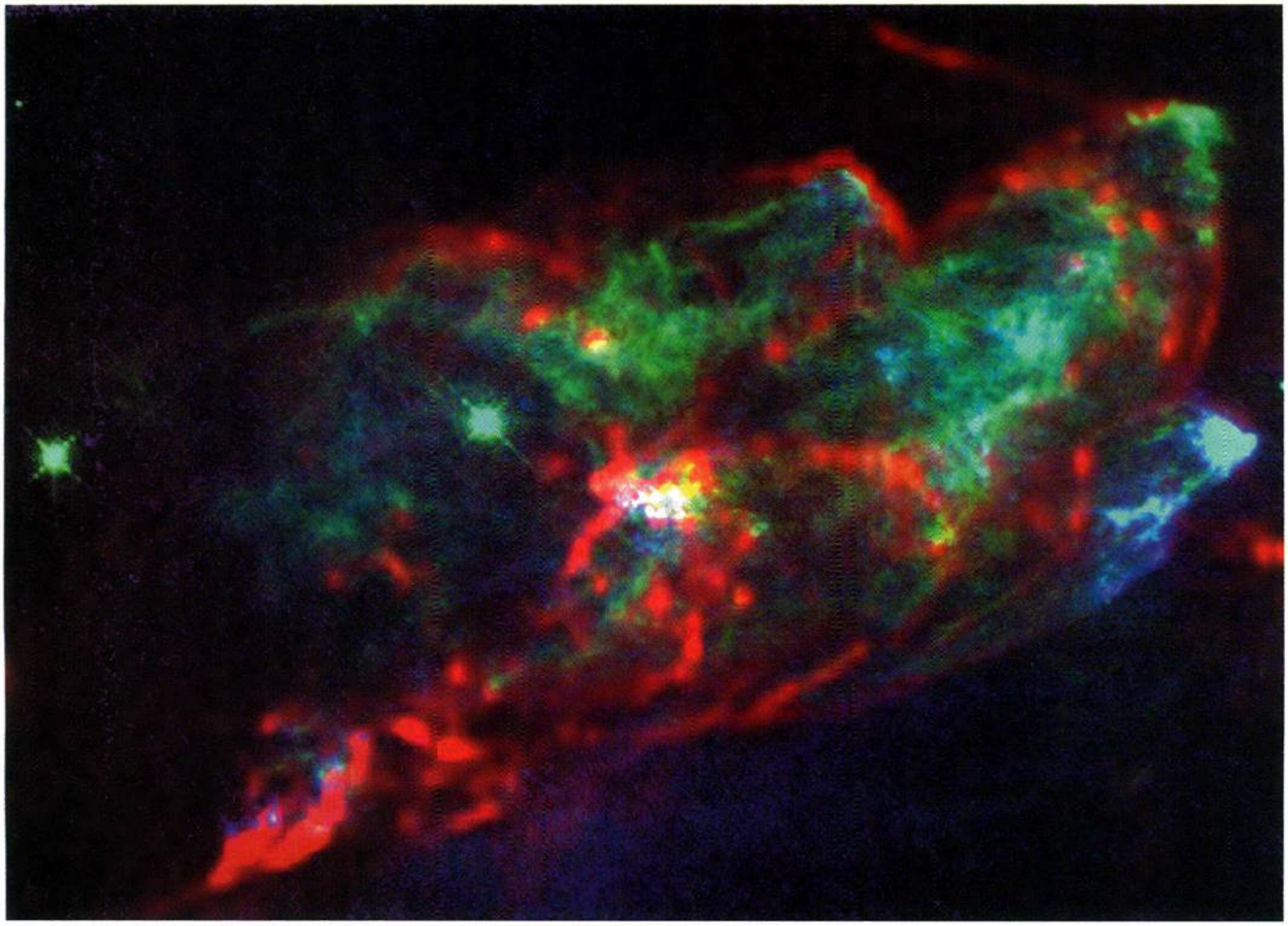
For his Ph.D., Shu went to Harvard, just a couple of miles up the Charles River from MIT. He continued to work closely with his old mentor Lin. His doctoral dissertation tackled the tough problem of why galaxies form spiral arms. It explained their structures as being due to compression waves propagating through the galaxy, which is still the leading theory. During his Harvard days he met his future wife, Helen Pu, who was an undergraduate at Wellesley College, just outside Boston. Today, the couple live near Menlo Park, where Helen works as a vice president for a biotechnology firm.

After completing his Ph.D., Shu was thinking about a job offer from Haverford College in Pennsylvania when he ran into astronomer Stephen Strom in the parking lot of the Harvard College Observatory. Shu had worked as a teaching assistant for Strom and knew him quite well. "Steve asked if I was interested in a job at the State University of New York at Stony Brook," Shu reminisces. It was an easy decision. Physicist C. N. Yang, a Nobel Prize winner, had recently moved to SUNY-Stony Brook. "He was very famous among Chinese-Americans and a personal idol of mine. So, a chance to work at the same place as him was very attractive to me," Shu explains.

Strom and Shu, who moved to Stony Brook in 1968, were among the first astronomers at the university. Together they helped build the department. Shu continued to work on spiral patterns in galaxies as well as shock waves in interstellar space. During a brief visit to Berkeley in 1971, he fell in love with the northern California city. When a

The process of starbirth begins in large clouds of gas and dust, such as M17.

Jason Ware



Patrick Hartigan (Rice University), Jon Morse (University of Colorado), et al., and NASA

As this Hubble image shows, young stars generate vast outflows, which ram into and heat the surrounding material.

faculty position opened up at Berkeley two years later, he took it and has been there ever since.

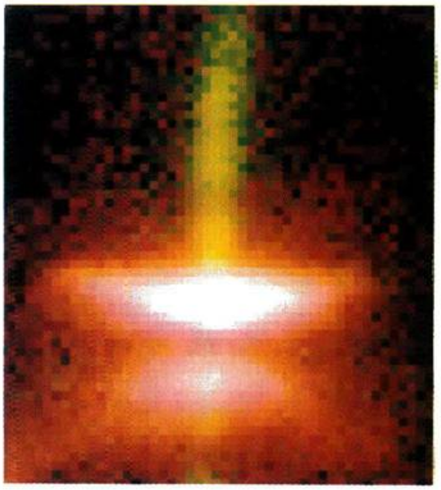
A new place led to a new interest: interacting binary stars. Together with Stephen Lubow, his first Ph.D. student, Shu worked out a mass transfer theory for so-called "semi-detached binaries," in which one star essentially gobbles up the other. They made quantitative estimates of the stream of material passing from one star to the other and showed that the heated material was responsible for x-ray emission. Later, they studied "contact binaries," star pairs surrounded by a common envelope of material. "This area became overly competitive and somewhat unpleasant," Shu recalls. "The debate became almost personal instead of purely scientific." That wasn't a happy period in Shu's professional life.

POOL SHARK

Again, an old mentor came to the rescue. While visiting Tucson, Arizona, around 1976, Shu had dinner with legendary astronomer Bart Bok. "I was talking to him about my unhappiness with the subject, and Bart said 'Why don't you work on star formation?'" recalls Shu. "I thought this was an interesting idea." When he returned to Berkeley, Shu looked through the literature on the theory of star formation.

Within a year, he published his own influential paper on the subject. Building on the ideas of Richard Larson at Yale University, Shu proposed an elegant model for how a giant cloud of gas and dust collapses into a protostar surrounded by a disk and an envelope. His calculations described the progression of the collapse and provided a mathematical and physical basis for later, more detailed, work on protostar formation. Ever since, Shu and his students have made refinements to the model, producing a body of work that accounts for much of what astronomers know about star formation today. "The big difference between Frank and most other theorists is that his theories are much more tied to observations," says Lada. "He isn't afraid to make himself vulnerable to observational scrutiny because he has confidence in his ideas."

Douglas Lin, an astronomer at the University of California, Santa Cruz,



Frank Shu's x-wind model explains how young stars and their disks shoot out jets of gas, as seen in this Hubble Space Telescope image.

Chris Burrows (STScI), the WFPC2 Science Team, and NASA agrees: "Frank interacts closely with observers and brings great physical insight and deep mathematical abilities to address any problem." Shu is also known to enjoy friendly competition. "He certainly enjoys a challenge," adds Lin, who often gets into amicable debates with Shu at scientific meetings.

Shu's competitive spirit is best seen in poker. "He's quite a poker player, and he likes to win," says Lin. He recalls sitting next to Shu on a flight from Tucson. Lin had to return to California while Shu was planning to stop over in Las Vegas where an AAS meeting was taking place. "I remember Frank telling me how important it was for young astronomers like myself to go to AAS meetings, to meet people, to exchange ideas, until I felt guilty for missing that meeting," says Lin. A week later, when his Santa Cruz colleagues returned from Las Vegas, Lin inquired whether they had seen Shu. Their answer: "He was at the meeting for the first three minutes. The rest of the time, he was at the poker table!" The next time they met, Lin asked Shu, "So, Frank, I hear you have some hidden vices?" Shu quickly retorted, "Not so hidden."

Shu also enjoys pool. "I'm an okay pool player, but not a great one," admits Shu. "I mainly use the pool table to take a break from typing on the computer when I work at home. Occasionally, I have friends come over to shoot some pool, and I win my share of the games, but not with the frequency at which I win in poker. I shoot pool for fun and I don't bet on games."

SIZING UP STARBIRTH

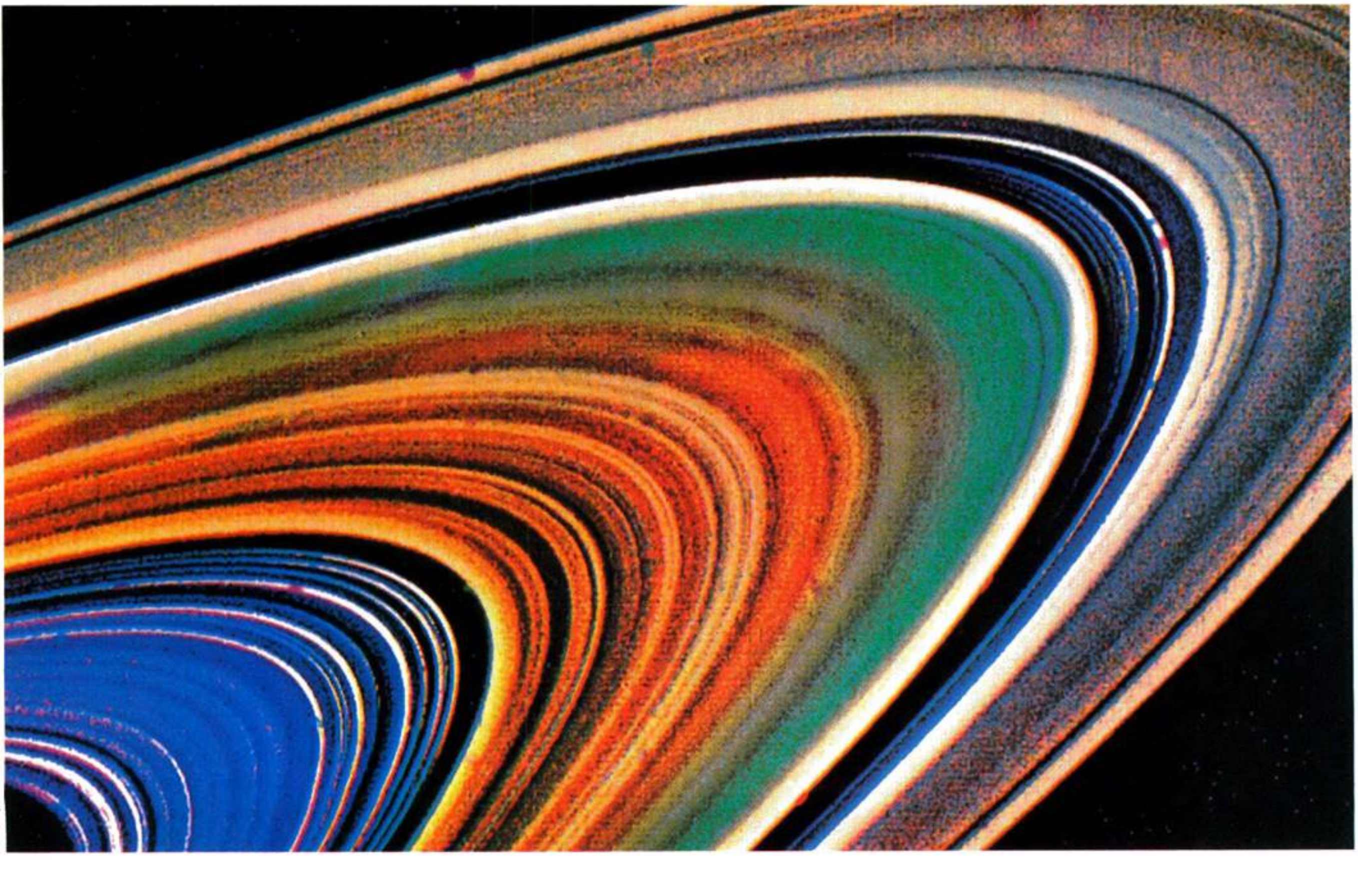
One "big" question stands out as a major puzzle and motivator in Shu's research: Why do stars form with the masses they do? "I thought it very peculiar that stars are gas balls with just the right mass range for thermonuclear fusion," explains Shu. After all, interstellar clouds of gas and dust contain hundreds or thousands of times the mass of the sun. Yet most stars are only between one-fourth and a few times the mass of the sun. What stops newborn stars from accreting more and more material from their surroundings? Why do they usually stop close to one solar mass? "That was a big puzzle," says Shu.

The crucial breakthrough, at least in Shu's mind, came from observations of bipolar outflows from protostars, jets of material shooting away from the star's poles. "If bipolar outflows are the mechanism that stops the infall, then this would of course limit the star's mass," Shu explains. "That's when it occurred to me that stars, at least at the lower mass end, may help determine their own masses."

Shu's idea was attractive, but it had competition. Other researchers have suggested that stellar masses are limited by the amount of material in "dense cores," pockets of gas and dust that form when portions of giant interstellar clouds collapse. While the clouds themselves are hundreds of solar masses in total, these dense cores, which collapse into stars, are much less massive.

In recent years, Shu and his students have developed a theory that explains how protostars generate outflows. Their model, known as the "x-wind," suggests that a young star's strong magnetic field lifts material off the inner edge of the disk to form a wind, sort of like an eggbeater throwing egg from the center of the bowl to the edge. One would expect an x-wind to appear more like a broad fan rather than a narrow jet. Images of protostars obtained by the Hubble Space Telescope clearly show narrow, bright jets and cavities formed by broader outflows. According to Shu, "That jet is only the densest part of the wind." The broader wind is too diffuse

Shu explained how the gravity of moons and moonlets creates gaps in Saturn's rings.



NASA/JPL

to see in Hubble pictures, he explains, pulling out a paper from the tall stacks crowding his desk as well as a couple of chairs in the office. Other theorists have argued that the broader wind originates from farther out in the disk, not from its inner edge. But Shu's x-wind model remains the leader in the field.

Shu has recently sought help from x-winds to solve another century-old puzzle. Planetary scientists have known that the most common meteorites, called chondrites, are a paradoxical mix of minerals that were once heated to high temperatures and others which clearly had a cold origin. Shu and his colleagues suggest that x-winds from the protosun lifted hot, fluffy rocks and then sprayed them in a fiery rain all over the primitive solar system. These "chondrules," or beads of melted rock, later combined with colder dust to form larger bodies such as asteroids and planets. They calculate that only those chondrules with sizes between a millimeter and a centimeter would fall back on the protoplanetary disk. That's just the range of chondrule sizes seen in meteorites.

Shu and his colleagues can even explain the presence of unusual radioactive elements found in meteorites. They suggest that the young sun must have generated energetic magnetic flares, similar to those detected a few years ago from several protostars by the Japanese x-ray satellite ASCA. The fast-moving protons in those flares would combine with ordinary elements in the protoplanetary disk to form their radioactive counterparts. "This is the first theory to explain all the disparate features of chondrites, such as the narrow range of sizes of chondrules and why their composition is different from that of the sun," says Shu.

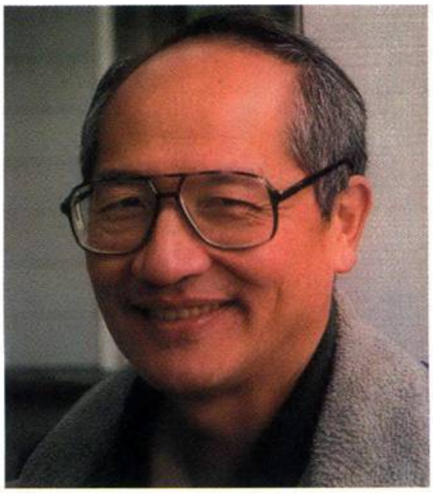
One of Shu's early heroes was Leonardo da Vinci.

VARIED INTERESTS

Even though star formation has been his primary research interest, Shu isn't afraid to wander into other areas of astronomy that catch his fancy. In the early 1980s, when the Voyager spacecraft were headed to the outer planets, he became interested in the structure of Saturn's rings. Shu's eyes light up when he recalls his foray into planetary science: "When Voyager 1 flew by Saturn, it was really exciting to see those images appear on the TV screen at the Jet Propulsion Lab and to see all that structure in the rings." Theorists usually have to wait years, or even decades, before their predictions are tested by observations. "Here we could do theory and get tested quickly and very accurately. That was extremely satisfying," says Shu. His model explained the detailed structure — gaps, brightness variations — in the rings as being due to the gravitational influence of Saturn's moons and moonlets.

Being primarily a theorist, Shu has observed with a telescope only twice in his life. The first time was in graduate school. When he had almost completed his Ph.D. thesis, his advisory committee decided that he was "too theoretical" and that he should get some observational experience. "So I was delayed from graduating by about eight months while I was doing an observational project," he says. Shu took spectra of young stars to study the amount of lithium in their atmosphere, an indicator of the star's youth because lithium burns up within a few million years.

The second time he went observing, it was on his own accord. When he was working on contact binaries, Shu came up with a clever idea: If you look at the peanut-shaped spectral lines of a contact binary, you should be able to construct an image of the pair of stars. In other words, the shape of the spectral lines tells you the geometry of the binary. He applied and was granted time at the University of California's Lick Observatory. "Since I was primarily known as a theorist, Don Osterbrock, the Lick director, started calling me up as our telescope time approached. First every week, then every other day, then every day," Shu recalls. "I assured him that I had a really good postdoc and that we weren't going to break anything!"


Raleigh Souther

With his outstanding teaching skills, Frank Shu has helped many budding young astronomers get started in their careers.

Shu is also known as a great teacher. David Ardila, a physics graduate student at Berkeley, recalls taking a course on gas dynamics taught by Shu. "When the weather got nice in the spring, he took us to a courtyard outside for lectures, so there was no blackboard for the last part of the course. The final set of lectures dealt with magnetohydrodynamics, a highly mathematical subject that's not easy to comprehend. Because there was no blackboard, he had to depend on hand gestures for explanations. Yet, his lectures were so clear that we understood this difficult subject."

His excellent rapport with students may have something to do with the success of his Ph.D. students over the years. Many have become influential astronomers in their own right, such as Fred Adams, Doug Johnstone, Joan Najita, and Sue Terebey. Shu's introductory astronomy textbook, *The Physical Universe*, is widely used at college level. His more advanced two-volume textbook *The Physics of Astrophysics* forms the basis for many graduate courses.

One of Shu's early heroes was Leonardo da Vinci. "Soon after we came to the United States, my father took us to an exhibition on da Vinci. I remember being really impressed by this guy who could draw, who could do science, who invented so many things — the definition of a Renaissance man." Perhaps that early impression has stayed with Shu to this day. He sees much in common between science and art. "The scientist at his or her purest is very similar to the artist. They have common goals, they're both searching for the truth. The difference is that scientific truth is external truth whereas the truth that a writer sees or a painter sees is inner truth."

Contributing editor Ray Jayawardhana studies star formation and circumstellar disks at the Harvard-Smithsonian Center for Astrophysics. His previous feature article for Astronomy *was "Pursuing the Planets" in the December 1999 issue.*

COLORS on the Moon?

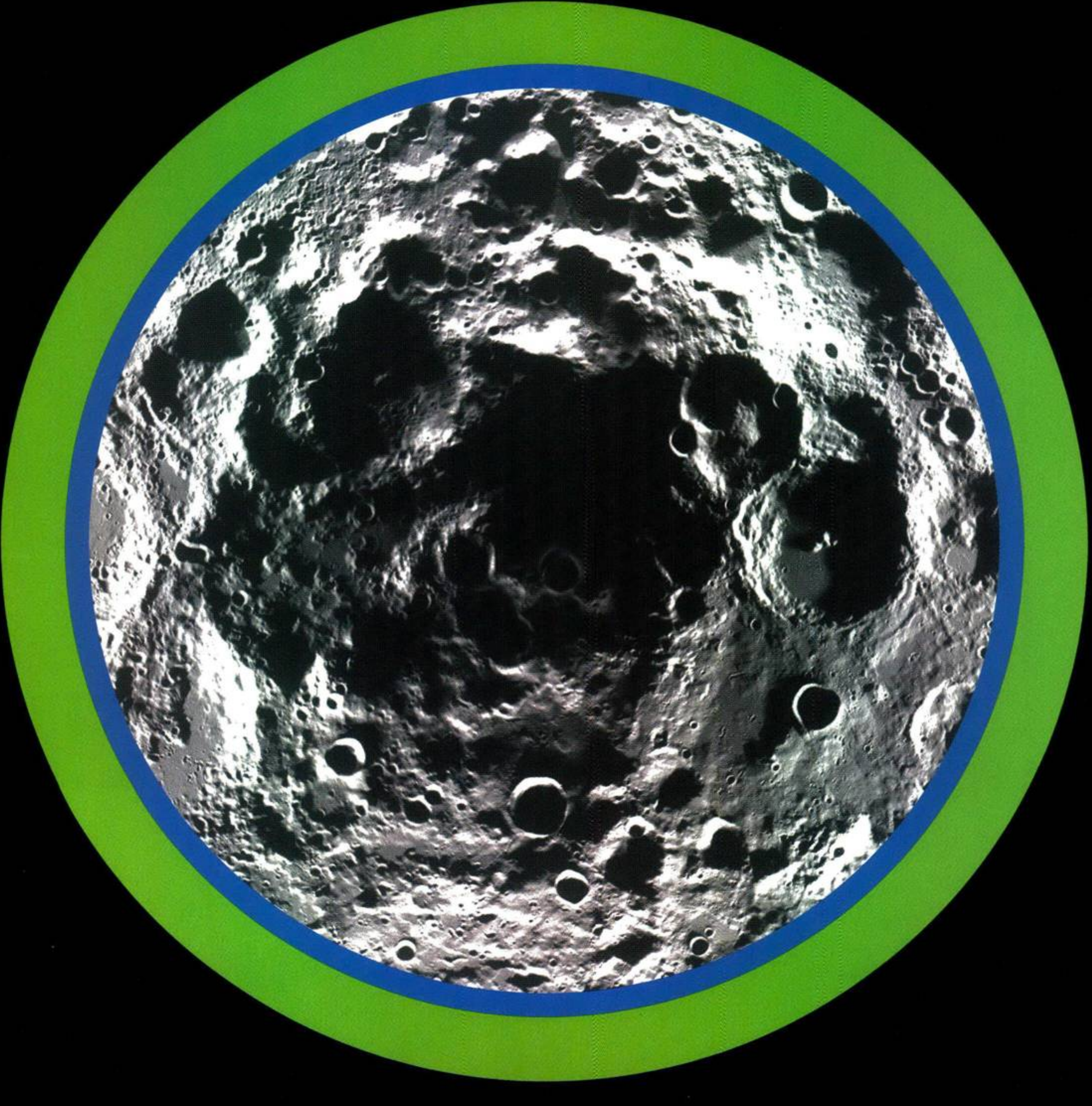
Subtle hues provide clues of violent impacts and a volcanic past.

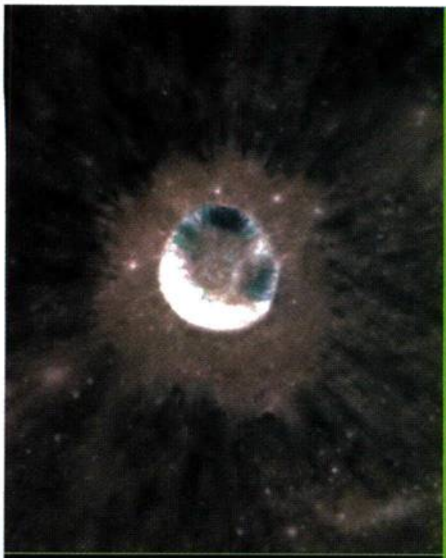
by Jim Bell

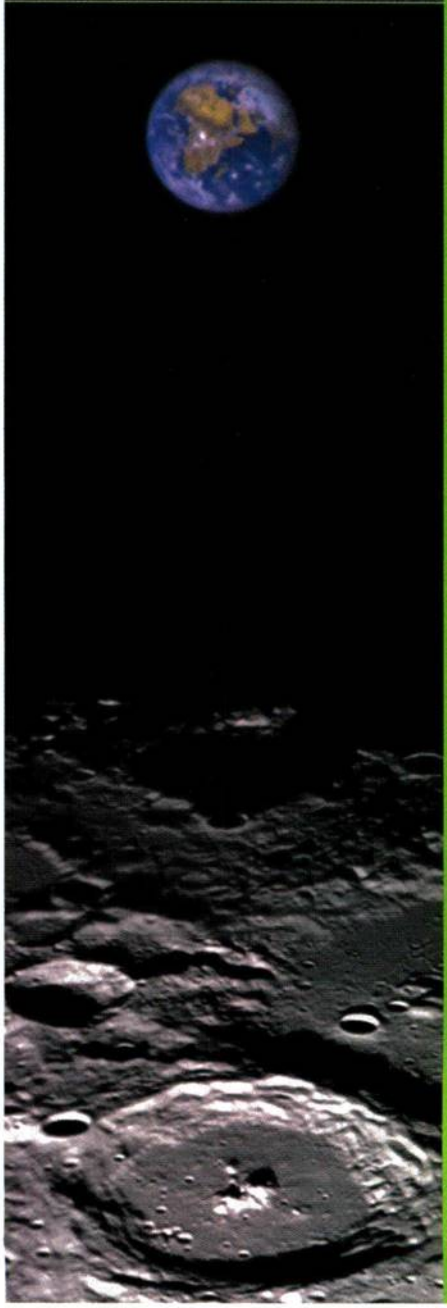
IN THE LATE 1960S, BLACK-AND-WHITE TELEVISION SETS WERE the norm, so the stark, colorless landscape explored by Apollo 11's astronauts and beamed back live to the awestruck world didn't seem unusual. I remember later, though, watching color movies of the astronauts' adventures and noticing the bright American flag and splashy colors of the lunar module's gold foil standing out against various shades of a dull lunar backdrop. A somewhat more distant view from my backyard telescope told me the same thing — the moon is painted only in shades of gray.

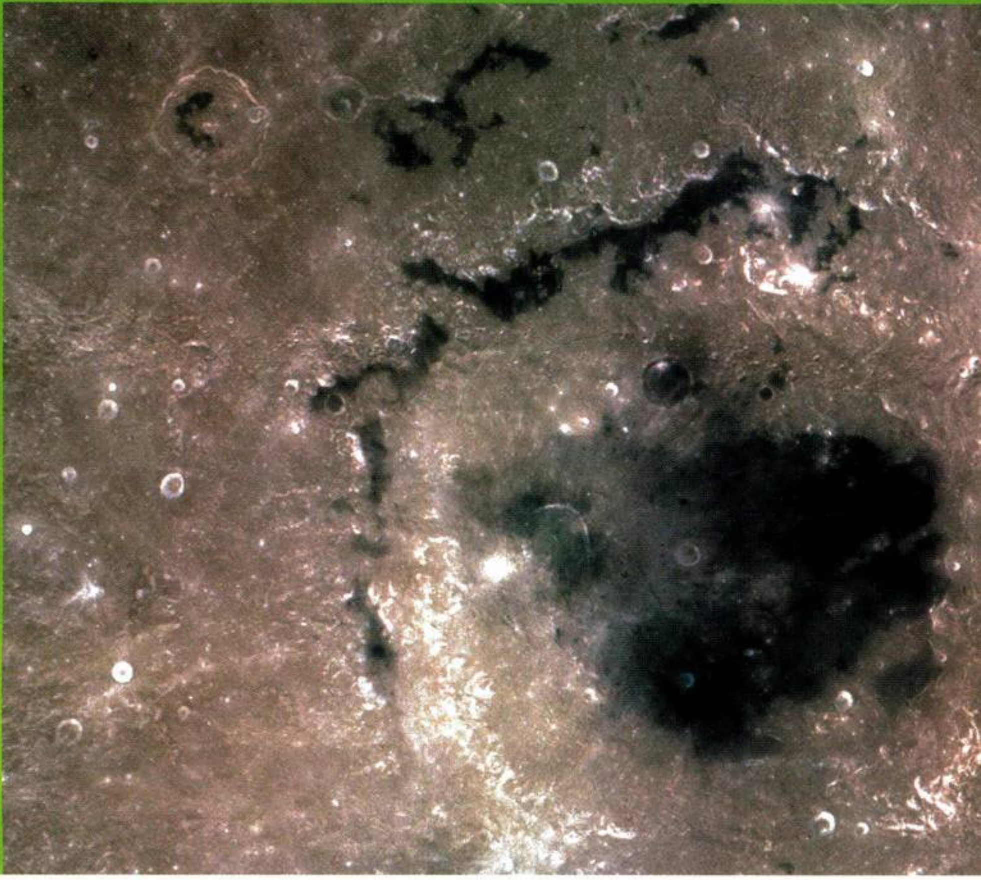
While our moon is virtually colorless, other celestial bodies — Earth, Mars, and Jupiter's moon Io — exhibit remarkable, beautiful colors. Blame it on absorption and reflection. Humans see only a tiny slice of the electromagnetic spectrum. Color is our

A close look inside the rim crest of the moon's south pole-Aitken Basin. All photos: NASA









limited perception of the way materials absorb and reflect light. An object or planet appears a certain color because competing wavelengths of light to which our eyes are sensitive get absorbed instead of reflected back to us. Materials split the visible spectrum according to their composition, providing us with a fingerprinting tool for the remote identification of planetary rocks, minerals, and atmospheric gases.

From space, Earth is blue because of an abundance of liquid water. Other shades and hues abound thanks to vegetation (green), oxidized rocks and soils (red), and snow, ice, and clouds (white). Our neighbor, Mars, owes its overall reddish tinge to a surface rich in oxidized iron. And Io's dynamic surface spews forth volcanic shades of sulfury reds, yellows, browns, and whites. For most orbiting bodies, surface color is a manifestation of active geologic processes involving either atmospheric gases and/or trace chemicals that modify the normal blacks and whites of typical volcanic surfaces. Color must be earned in the solar system.

COLOR must be earned in the solar system.

Most of the moon's geologic activity ended a billion years or so after its formation. In the roughly 3.5 billion years since, the lunar surface changed little, retaining the bland hues of materials formed early in its history. Surface weathering of the moon occurs through bombardment by cosmic particles and solar winds, producing the regolith, or powdery surface detritus deposited in varying depths depending on the moon's topography.

With the exception of the microscopic-yet-abundant glasses formed by meteorite impact, the moon appears colorless. Brilliant emerald green and orange glasses collected by astronauts during the Apollo 15 and Apollo 17 moon missions, respectively, differ from glasses of impact origin. Rather, scientists believe that these highly colored glasses resulted from ancient lava effusions. "Fire fountaining," where lava eruptions spray homogeneous glass spherules over lunar surfaces, best explains the origin of these glasses.

When we broaden our vision by using a telescope equipped with a CCD camera — which is sensitive to more of the electromagnetic spectrum than our eyes — our range of color perception gets substantially enhanced. The moon's rocks and minerals exhibit much more variation in color in the ultraviolet and near-infrared ranges. Lunar color variations were first detected by astronomers in the 1960s using special UV-sensitive photographic film; today's CCD camera and filter technologies make these types of extended color measurements well within reach of many amateur astronomers.

Viewing the moon in extended color using ultraviolet and infrared imaging displays surface nuances invisible to the unaided eye. What appears as almost uniformly dark mare patches are actually areas composed of two kinds of substances, one relatively blue and the other relatively red. Studies of the color and mineralogy of Earth and moon rocks reveal that this color difference is related to the abundance of iron and titanium and volcanically or glass impact-generated particles in the rocks.

Mapping these color differences helps chart the chemistry and mineralogy of the lunar surface and provides a way to distinguish among several types of volcanic minerals. Extended colors of impact craters provide information on the moon's interior and geologic past. Craters display extended color properties partly because different minerals get exposed on impact and partly because the strength of the extended colors change as the crater ages.

Astronomers obtain extended color CCD images from NASA's lunar-orbiting Clementine spacecraft to examine the moon's color variations. If you have a CCD camera and telescope and can invest in a few far-blue and far-red filters in addition to your normal color set, teasing out the moon's subtle colors is within your grasp. Whether walking at night in the colorless glow of moonlight or gazing through the eyepiece at our old and gray celestial neighbor, it's nice to know that even this "coldhearted orb" has earned its colors through time. ▣

Clementine images, clockwise from top left: Dionysius crater on the edge of Mare Tranquillitatis shows striking contrasts; moon's north pole; the Aristarchus plateau reveals subtle blues, greens, and reds; dark mare lava partially fills Orientale Basin; overlooking Plaskett Crater to a full view of Earth.

Frequent contributor Jim Bell is a planetary astronomer at Cornell University and is writing a book on Mars exploration.

SETI and the SCIENCE WARS

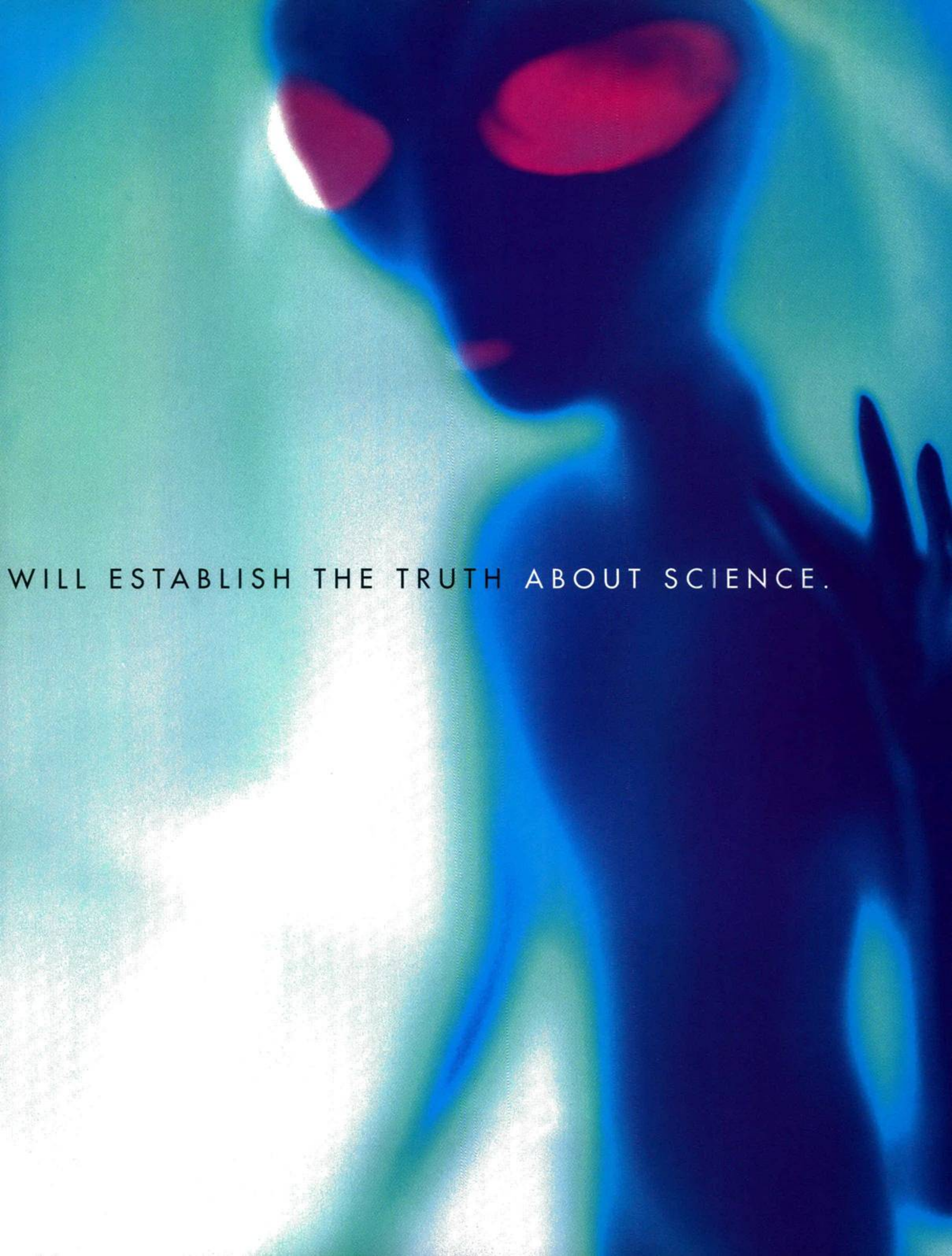
TEXT BY DAVID GRINSPOON & PHOTO ILLUSTRATIONS BY STEVE PUETZER

HOW CONTACT WITH INTELLIGENT ALIENS

If and when we finally make contact with an alien civilization, will we be able to understand each others' science? An answer to this question could put science in its place in a way that nothing else could.

Have you heard about the "science wars" currently raging in academia? If not, you're luckier than I am. At the core of this conflict are some vital questions regarding the nature of scientific knowledge and the quest for objective truth, questions that have become stuck in a quagmire of obscure academic debate.

The wars have arisen in response to the advent of "science studies" — which seek to study the culture of science and the nature of scientific knowledge. Many scientists I know wish that science studies would just go away. Some of this acrimony is due to cultural differences between the sciences and humanities, in particular to differences in language and writing style.



WILL ESTABLISH THE TRUTH ABOUT SCIENCE.

HOW MUCH SCIENCE IS INVENTED AND HOW MUCH IS DISCOVERED?

What really rubs some scientists wrong is the postmodernist penchant for dismissing scientific knowledge as culturally derived. The extreme relativist position would claim that a scientific paper is just another text, another story wholly constructed in the culturally embedded mind of the scientist and subject to his or her particular biases and experiences. So if Newton had been born in another place and time would his inverse square law of gravity have been an inverse cube law, with falling bodies following different paths? I don't think so. Most anyone who has experienced scientific discovery has a strong conviction that the universe is trying to tell us something. We know that, however imperfect our process, we are on to something real. It's insulting to be told that our results are illusion and social construct.

On the other hand, the history of science is one of indirect progress toward elusive goals. It is full of false starts, dead ends, and fads. We have found ourselves stuck for decades in temporary cul-de-sacs, with consensus masquerading as ultimate truth. How do we know which of our current truths will one day be found to be just one of these temporary diversions?

NO TRUTH?

Looking at the history of science in this way makes it clear that, at any given historical moment, scientific knowledge is culturally specific. This doesn't mean that there is no objective truth that we can discover, only that any knowledge we have of it is limited. We approach the truth on a certain trajectory that is culturally and historically determined. Thus Newton's gravity has not been shown to be wrong but revealed by Einstein to result from the geometry of spacetime. In the same way, Einstein's visions will no doubt be encompassed by an even larger framework. Everyone knows that plate tectonics and continental drift are the ways of the world, yet less than 50 years ago these were seen by most Earth scientists as heretical and wacky schemes. The timing of these discoveries and the way in which they've become accepted by scientists and later percolated out to the average Joe are highly dependent on history and culture. So in these respects science is culturally determined. The interesting question then is to what extent is current science actually revealing to us some bedrock reality of our universe?

Certainly scientists should be at least as interested in these questions as sociologists, philosophers, and historians. The subject of science studies is a valid and fascinating one even if some of its more vocal practitioners advocate extreme views that are at odds with the intuition of working scientists. These, of course, trigger nasty, extreme responses. Clearly the entrenched partisans of either side need to get out more. The "wars" are largely the product of academic compartmentalization and the unnecessary divide between science and the humanities. The core question remains: How much of science is invented and how much is discovered?

How do we test our scientific knowledge to see if it is really universal? The answer lies in SETI: The Search for Extraterrestrial Intelligence. Our current radio searches do not need further justification. They are an inexpensive way to possibly address one of the most profound questions we can formulate: Are we alone, or do we have living, thinking counterparts in the Galaxy? But SETI can also serve as perhaps the ultimate test of the relativistic or absolute nature of scientific knowledge. If we make contact with ETs and can communicate with them, then we will find out if we both have discovered the same physical laws. It doesn't seem likely that their music, poetry, art, or literature will resemble ours, if they have anything that even fits in these categories. But if we are right that our scientific laws are intrinsic to the universe, not just our imaginations, then ET should have discovered the same natural laws. And this would constitute proof of the absolute, objective nature of some scientific truths.

It is tantalizing to think that we might be able to learn from the scientists of another thinking species and to see how closely their models of atomic and molecular structure resemble ours. It seems possible to me that some kind of science will be the one thing that we have in common with them. (Although, who knows, maybe they'll also enjoy gangsta rap and *The Simpsons.*)

Actually, we will never be able to find them at all with our current methods if our science is not, in some sense, universal. Radio communication seems to us a good way of sending information across the void, so we imagine ET will reach the same conclusion. We picture a universe full of creatures, probably carbon-based, searching the sky and occasionally broadcasting with parabolic radio telescopes. This requires them to have investigated the same universe with whatever kinds of minds they have and discovered some of the same physics. So, although we do not usually think of it as such, our participation in these searches is really an act of faith. SETI requires faith in the possibility of universal scientific knowledge that transcends galaxy of origin.

DECODING A MESSAGE

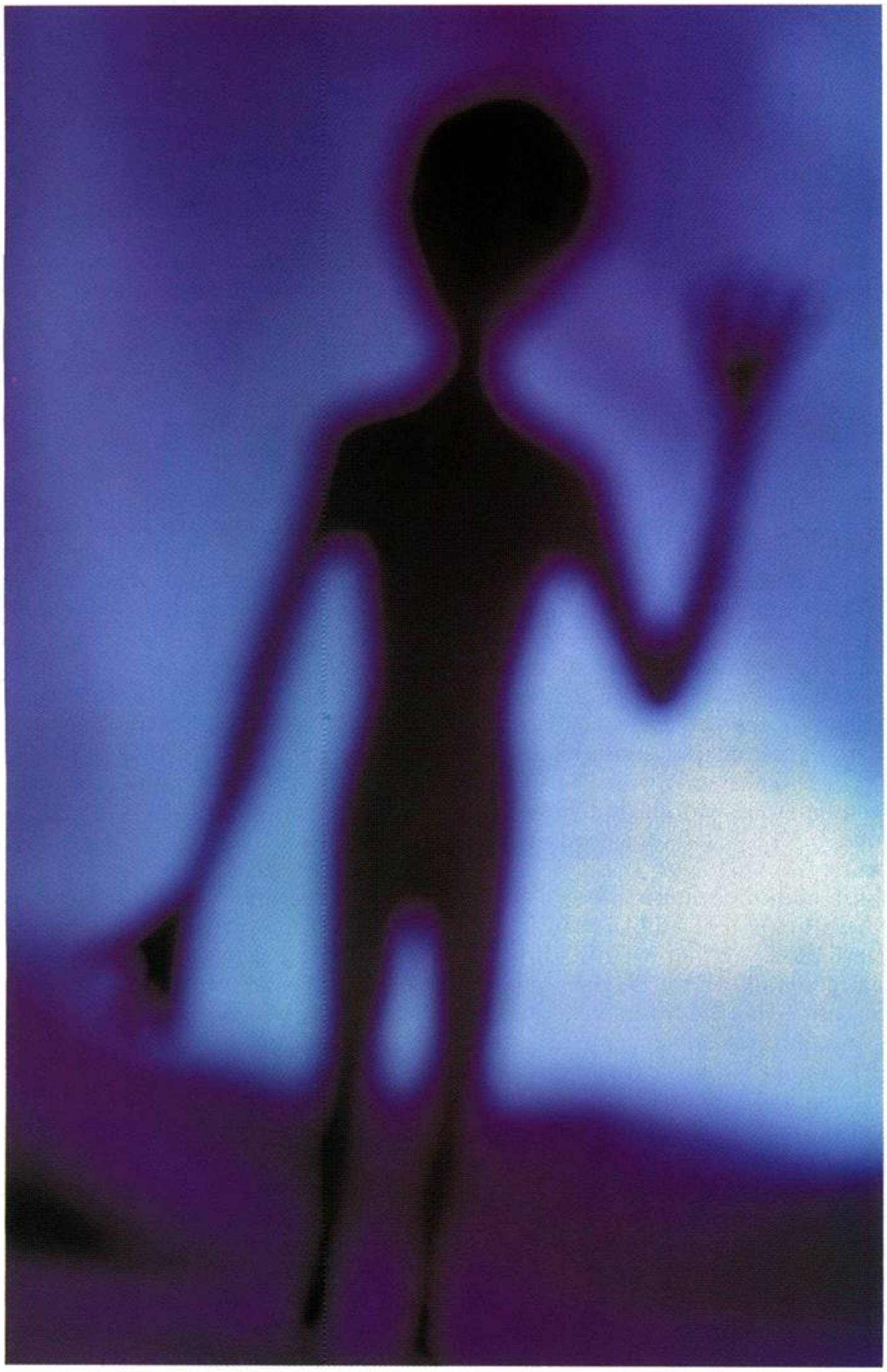
This point is further amplified if you think of the content of any message we might send to possible ETs. Indeed, built into the messages that have already been constructed and the theory about how to decode a discovered message are the assumptions of a common interstellar scientific language. Think of the famous Pioneer plaque, for example, the first physical message launched beyond our solar system, with its diagrams of human bodies, the solar system, and other information. Why do we believe that such a message will be decipherable, that ETs will understand our drawings of hydrogen atoms and our binary arithmetic? Because anyone reading it will have evolved in the same universe in which we find ourselves.

Wherever they live, hydrogen also has one proton and one electron. If they've intercepted the Pioneer craft, then they have some kind of science and technology. We assume that they will know what hydrogen atoms, planets, and pulsars are. We imagine our science to be so good and our models so powerful that they will be recognizable to others with whom we have nothing in common but our universe of origin. But if atoms and molecules

FOR SETI TO WORK REQUIRES THAT WE HAVE DISCOVERED SOME TRUE ASPECT OF THE UNIVERSE.

are constructs of our imaginations, then why should we expect aliens to have similar concepts? It is no coincidence that many SETI pioneers have been members of skeptics organizations advocating a hard-core materialist world view, not tolerant of alternative interpretations of nature. A reductionist, universalist scientific philosophy is an unspoken assumption of SETI.

Ironically, SETI itself may be one of the best examples of a socially constructed science. Since it is, at least as of this writing, a science without a subject, it consists largely of reasoned speculation about possible ET civilizations. A lot of this involves trying to second-guess the behavior and motives of alien races. This inevitably requires extrapolations from certain interpretations of our own history and possible futures. For example, at a recent meeting, scientists argued over whether advanced aliens would bother to actually travel interstellar distances or would prefer to stay at home and send radio messages. Interstellar travel, it was argued, would simply be too expensive and time-consuming so there's no way that any intelligent alien race would make the journey, and this explains why — in a universe so full of potential homes for creatures and civilizations — we haven't encountered any. Other arguments drew on analogies from Earth history, deriving patterns from the golden age of ocean navigation and extrapolating to theories of alien interstellar migration. It is easy to see how this kind of science is hugely dependent on our own biases, assumptions, and culture. I am highly suspicious of any theory of alien behavior that rests on analogies from or extensions of our own history or experience. My hunch is that alien behavior will be disturbingly strange and inexplicable to us.



LEAP OF FAITH

Yet I do believe that there are some universals that we will recognize in the alien version of the Richard Feynman Lectures on Physics. Unlike some hard-core skeptics, I recognize that this belief is based in part on faith. But I argue that my kind of faith in universal scientific truths is testable. For SETI to work requires that we have discovered some true aspect of the universe. Therefore, SETI is a test of our faith in science, a test of the nature of scientific truth.

Are scientific truths invented or discovered by humans? Are our scientific laws and discoveries constructs of the human mind or are they revelations of aspects of nature that exist completely independently of us? One surefire way to find out would be to borrow a physics textbook from the nearest ET and compare notes.

Planetary scientist David Grinspoon writes frequently for Astronomy, *but his day job at the Southwest Research Institute in Colorado focuses on Venus.*

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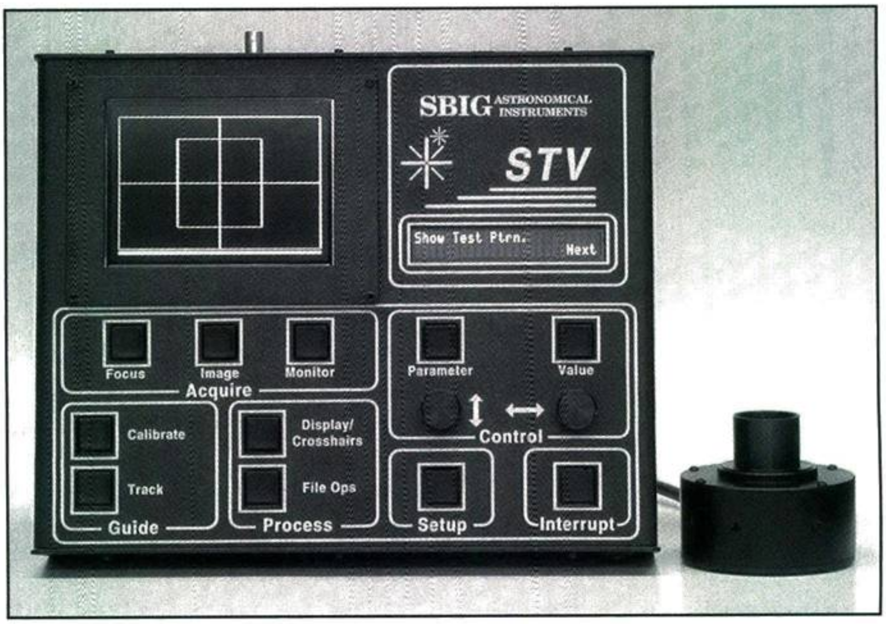
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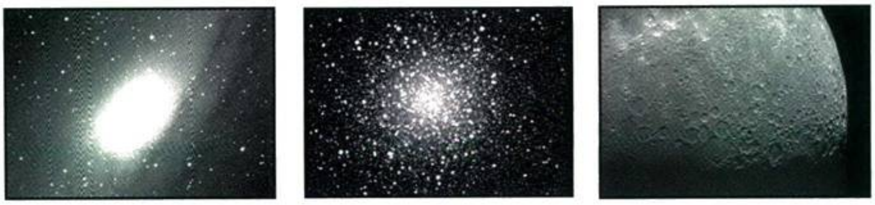

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COME TO THE

A midsummer night's darkness affords you the opportunity to reacquaint yourself with elusive dark nebulae.

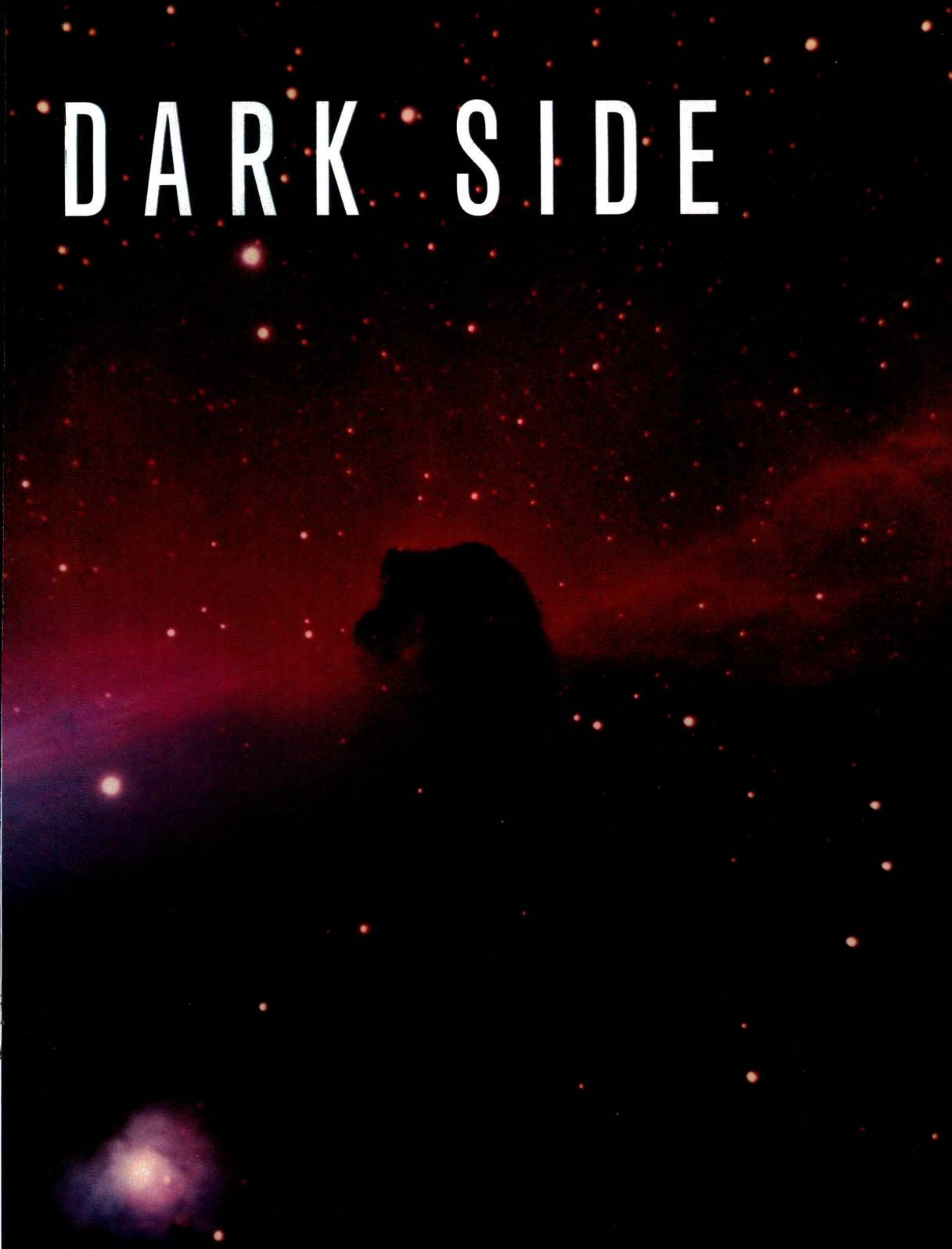
by Kelly Kizer Whitt

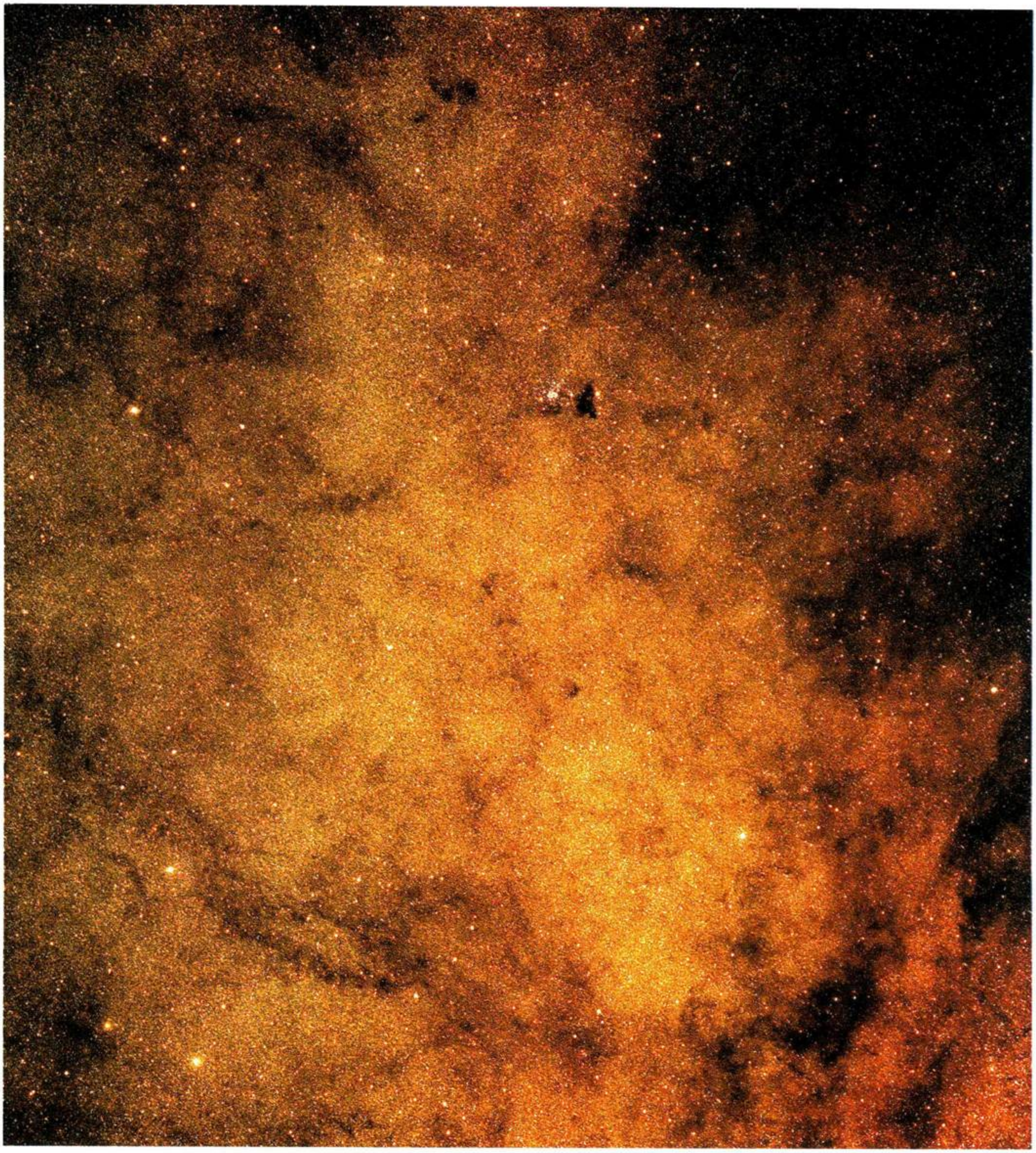
Observers and astrophotographers generally favor the bright objects in the night sky: the Andromeda Galaxy, Jupiter, the Pleiades; the list could go on and on. But there's a dark side to the sky, too. Areas where gas and dust block the starlight from reaching our eyes, creating dark and mysterious shapes.

These dark, or absorption, nebulae are clouds of gas and dust that absorb or scatter the light from a neighboring object. They consist mostly of carbon soot particles no larger than those in cigarette smoke. Background light sources allow these nebulae to be seen in silhouette. Edward Emerson Barnard drew attention to these objects in 1927 when he published a "Catalogue of 349 Dark Objects in the Sky" in his book *A Photographic Atlas of Selected Regions of the Milky Way*. Most dark nebulae can be referred to by their catalog number, which begins with a "B" for Barnard.

The Horsehead Nebula is the most recognizable dark nebula even though it is one of the most difficult to see. Jason Ware

DARK SIDE





Michael Stecker

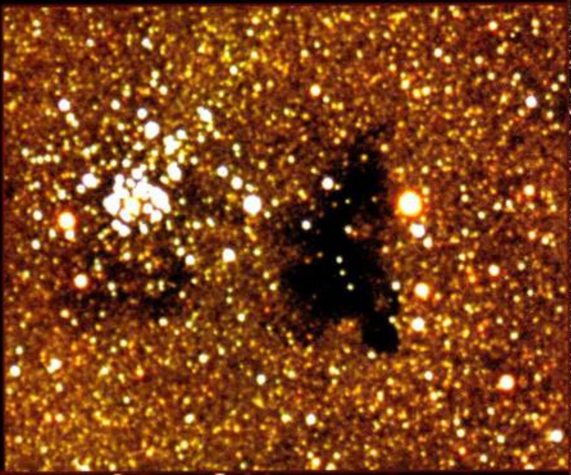
Toward the upper middle portion of the Large Sagittarius Star Cloud lies the dark nebula B86, next to the star cluster NGC 6520.

The most famous example of a dark nebula, the Horsehead (B33) in Orion, is among the more difficult to see, even with a large telescope. Thanks to photography, we are now able to view many of these dark nebulae that would otherwise be invisible.

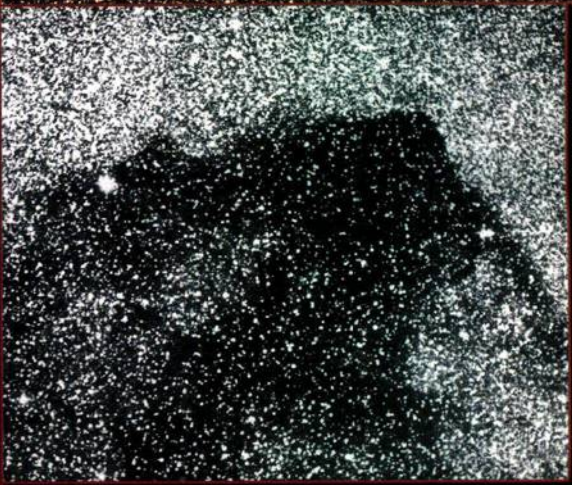
Dark nebulae that are possible to see require dark, rural skies and an evening close to new moon. One of the easiest groups of dark nebulae to see is the Great Rift in the Milky Way, visible with the eye alone. The Great Rift appears as a dark swath bisecting the thickest part of the Galaxy. The crowded, starry regions of the Galaxy make brilliant settings from which to search for naked-eye or binocular absorption nebulae that float before the stars.

In Ophiuchus lies the Pipe Nebula, which consists of a number of dark nebulae that span about 7°. The cloud shapes conjure up the image of a pipe with smoke billowing from its bowl. Starting at the bowl of the pipe moving outward along the stem are the dark nebulae B78, B59, B65, B66, and B67. The "smoke" that appears to emanate from the pipe

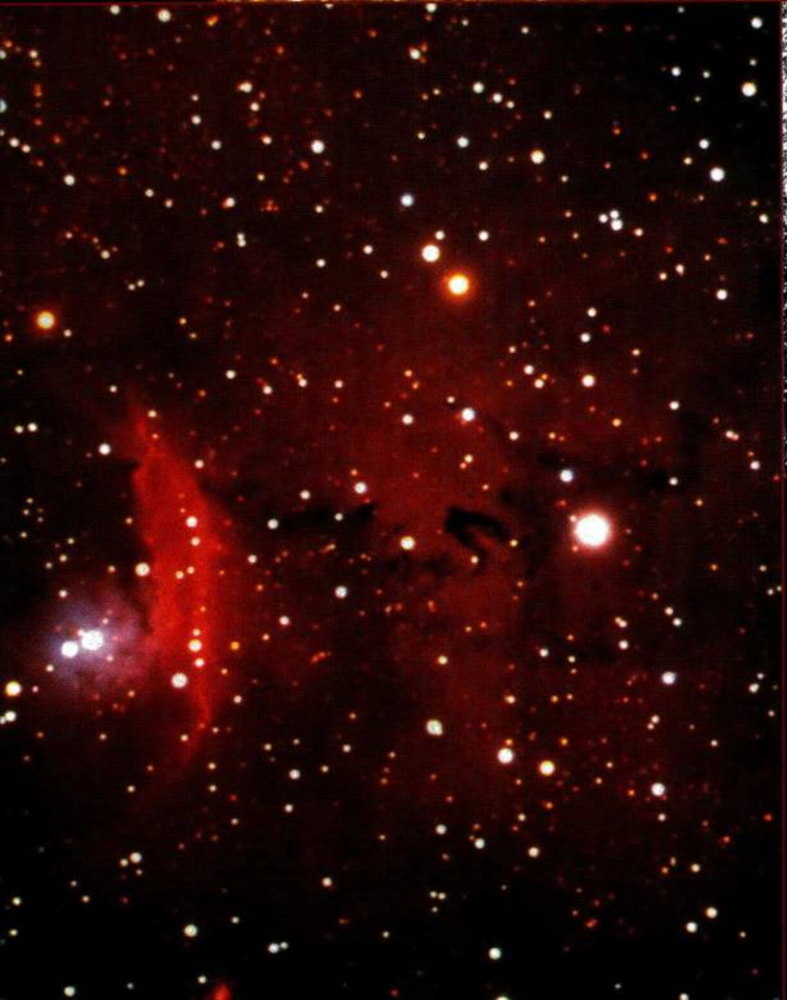
This pair of dark nebulae, B142 and B143, resides in Aquila. Michael Stecker



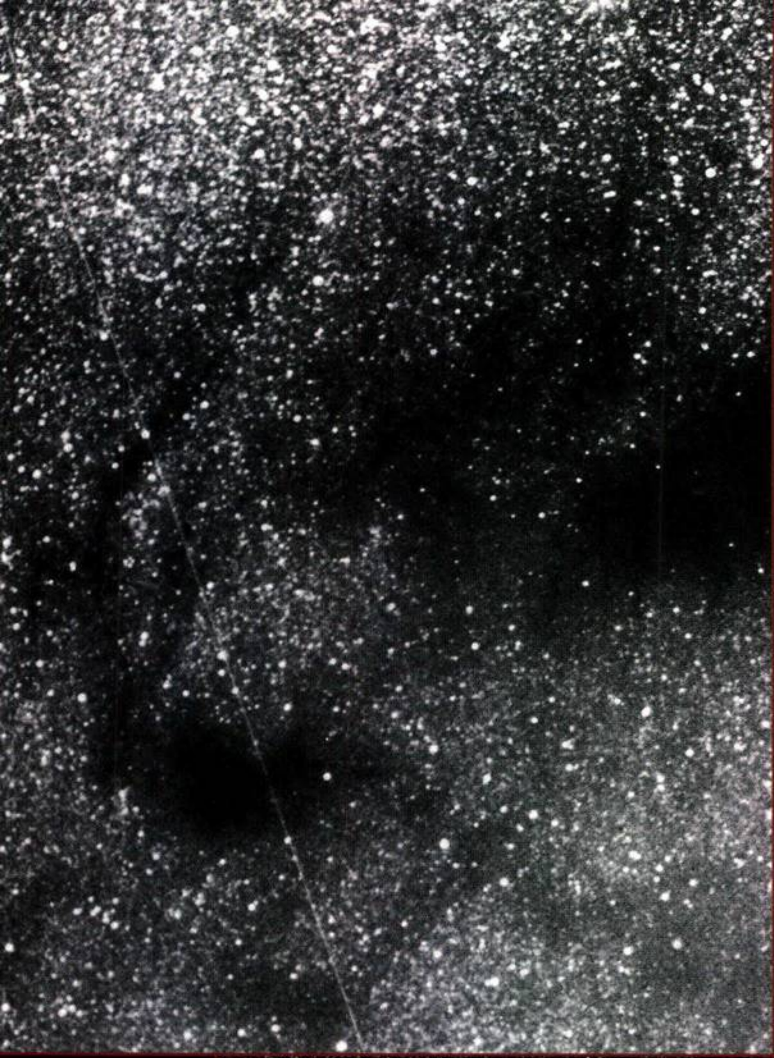
A magnified view of B86 shows why it is so easy to see compared to its background. Michael Stecker



The little constellation Scutum contains B312, which looks similar to an angelfish. Martin C. Germano

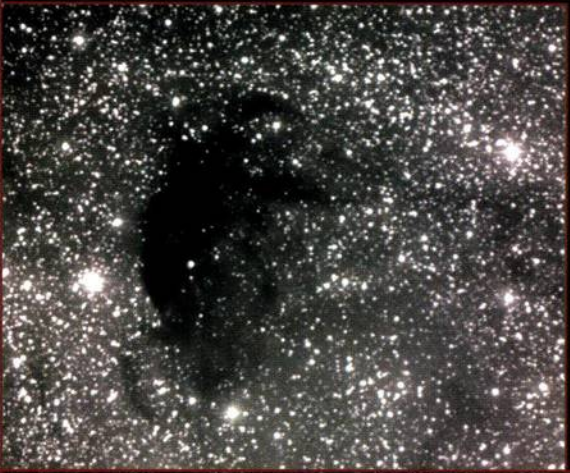


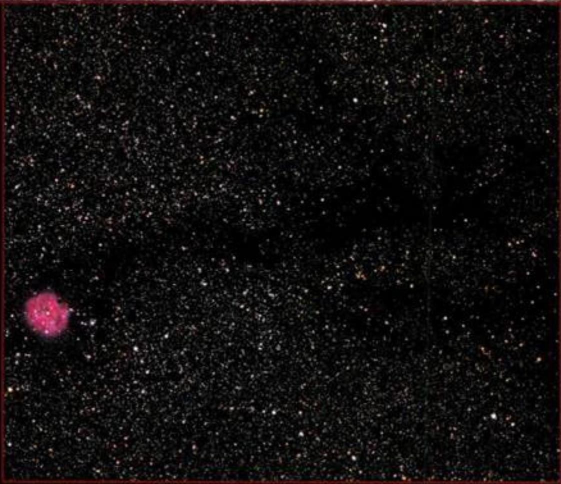
A squiggley-shaped dark nebula, B303, resides in Sagittarius. James R. Foster



A portion of the stem of the Pipe Nebula in Ophiuchus is sliced by a satellite at left. Martin C. Germano

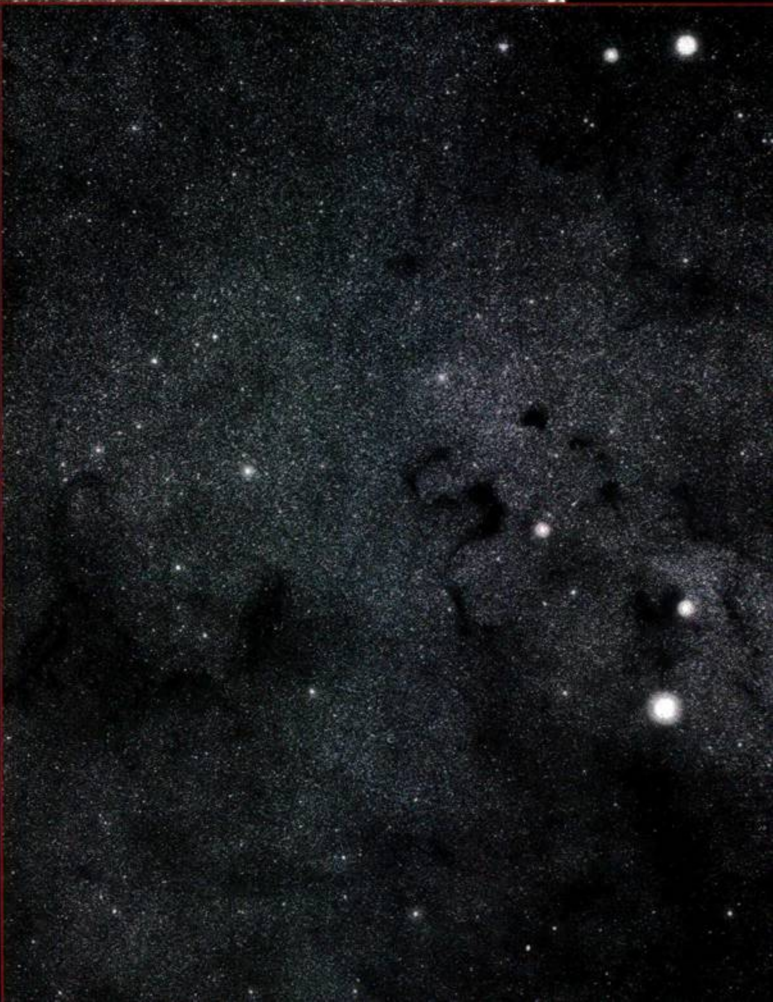
Absorption nebula B92 blocks out part of the Small Sagittarius Star Could. Martin C. Germano

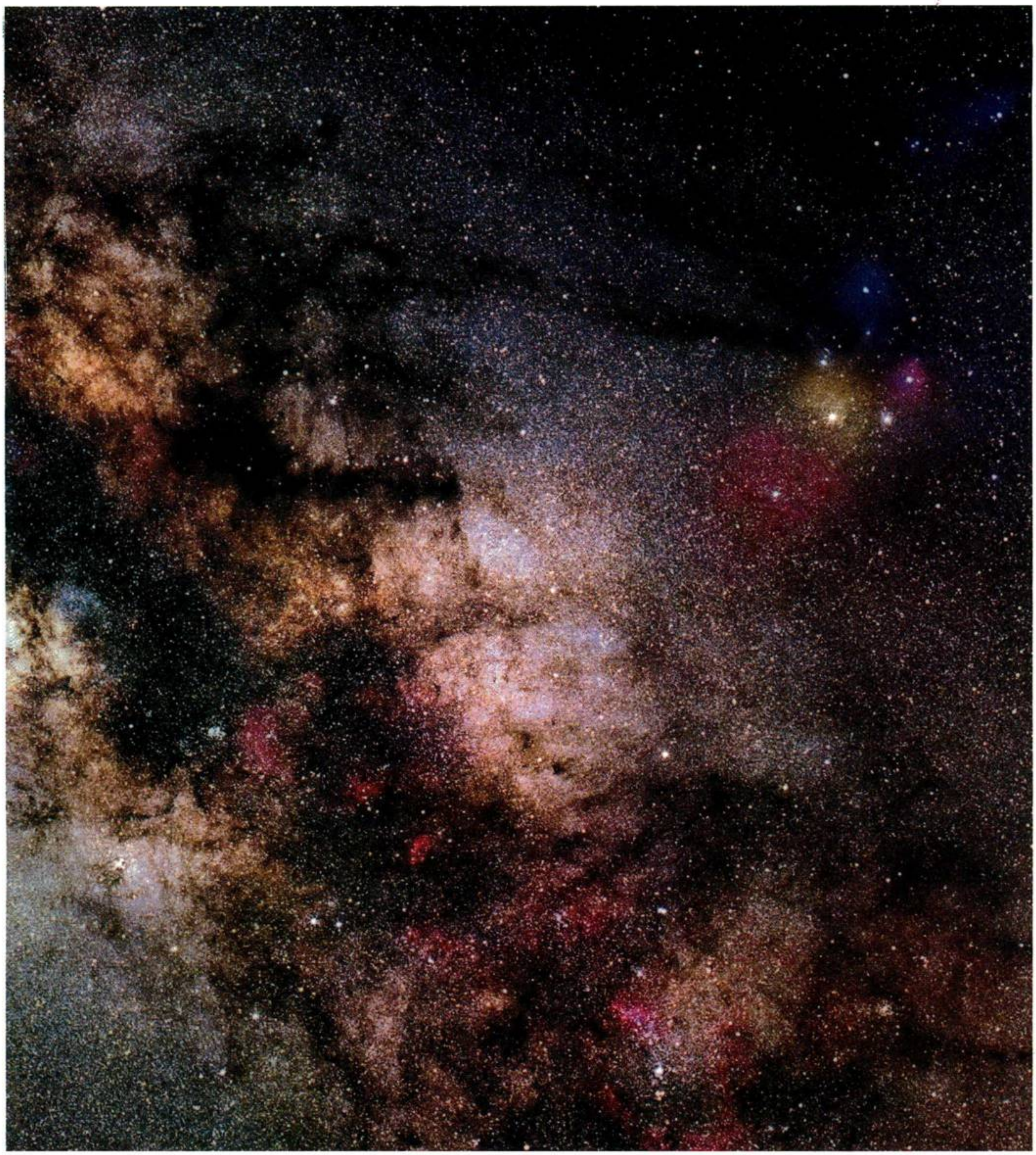




In Cygnus, the Cocoon Nebula has become a much-photographed object, and B168 extends off its eastern edge. In a dark location, B168 can be seen with a large pair of binoculars. Michael Stecker

A wide-field view of the S Nebula environs reveals many other odd-shaped dark nebulae in the smoke of the pipe. Brad D. Wallis





Tony and Daphne Hallas

In Ophiuchus, the Milky Way makes for an excellent backdrop when looking for dark nebulae. The Pipe Nebula is visible at the left center.

can be traced all the way back to the colorful Rho (ρ) Ophiuchi region. With the aid of a telescope at low power and a wide-angle lens you might be able to find an S-shape in the smoke. The S Nebula (Snake Nebula, B72) winds 30' in length. Just off the "head of the snake" lies a black globule, a dense region of dust rapidly coalescing into an infant star.

Another dark nebula made visible due to its position along the Milky Way is B86. The tightly packed stars in the claustrophobic area known as the Large Sagittarius Star Cloud form the backdrop. Easily visible through a telescope, B86 lies 2.7° north and a little west of Gamma (γ) Sagittarii. Look for the bright open cluster NGC 6520 adjacent to B86. Nearby you'll find B92, which marks the northwest corner of the Small Sagittarius Star Cloud.

Many other dark nebulae await your discovery. The pictures here can help familiarize you with their appearance, and a good star atlas can help locate them. Have fun this summer in the dark, getting to know some new favorite celestial wonders.

THE SKY SHOW

Observers indulge in the Eta Aquarids, a new comet, and a great conjunction.

by Martin Ratcliffe and Alister Ling

▶ The long-awaited, though invisible, conjunction of five planets occurs during the first two weeks of May. **Mercury**, **Venus**, **Mars**, **Jupiter**, and **Saturn** all lie on the far side of the sun as seen from Earth, spanning a 27° stretch of sky on May 3. The moon is also included in the collection. Two weeks later, on May 17, the six bodies minus the moon stretch out across only 19.5° of the sky.

The grouping cannot be seen because the sun is in the way. In reality, the planets, as always, lie far apart — this grouping is merely a line of sight effect, but nonetheless unusual. It is sure to spark some media attention (see Strange Universe, page 93).

Mercury makes a brief appearance in the evening sky after sunset. Look for it low in the west on May 19 when it shines at magnitude −1.2. Mars lies 1.1° to the south-southwest of Mercury but is practically invisible at magnitude 1.5 in the bright twilight just a half hour after sunset. Mercury itself dims rapidly as it moves away from the solar glow but becomes visible in a dark sky, setting almost two hours after the sun on May 31 at magnitude −0.2, making it an easy target. It reaches greatest elongation early next month.

The final vestiges of the winter sky descend in the west. During early May evenings, Orion hangs temporarily over the western horizon, soon to be swallowed by the encroaching twilight of the advancing summer. As with all stars, the bright beacons set four minutes earlier each day — a symptom of Earth's true rotation being four minutes shorter than our 24-hour clocks. Take Gemini for example: On May 1, the entire constellation, with its two recognizable bright stars Castor and Pollux, can be seen in a dark sky above the western horizon after 11 P.M. local time. By May 31 Gemini lies in the same location relative to the horizon, but now in a bright, twilit sky two hours earlier.

As Gemini sets, it takes along with it the hazy curtain of the Milky Way. Look to the northeast and you'll

A star party is a great opportunity to get out and share your love of observing with others. Under dark skies, you might even catch a stray meteor or two.

Richard Berry

MAY 2000

4 New moon is at 12:12 A.M. EDT
Eta Aquarid meteor shower peaks (page 70)

5 The moon passes 5° south of Mars, 2 A.M. EDT

6 The moon is at perigee (225,663 miles from Earth), 5:07 A.M. EDT

7 Jupiter is in conjunction with the sun, midnight EDT

8 Neptune is stationary, 9 A.M. EDT
Mercury is in superior conjunction, midnight EDT

10 First quarter moon is at 4:00 P.M. EDT
Saturn is in conjunction with the sun, 4 P.M. EDT

18 Full moon is at 3:34 A.M. EDT
Mars passes 6° north of Aldebaran, 11 P.M. EDT

19 Mercury passes 7° north of Aldebaran, 7 A.M. EDT
Mercury passes 1.1° north of Mars, 11 A.M. EDT

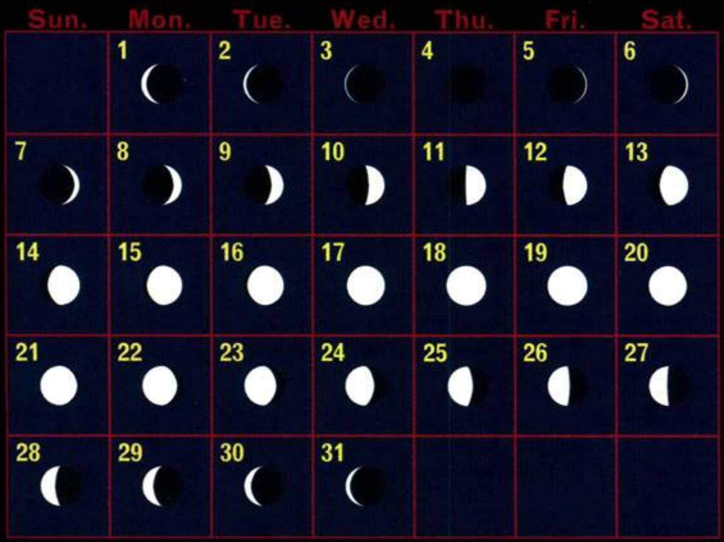
21 The moon is at apogee (251,921 miles from Earth), 11:58 P.M. EDT

23 The moon passes 1.2° south of Neptune, 10 P.M. EDT

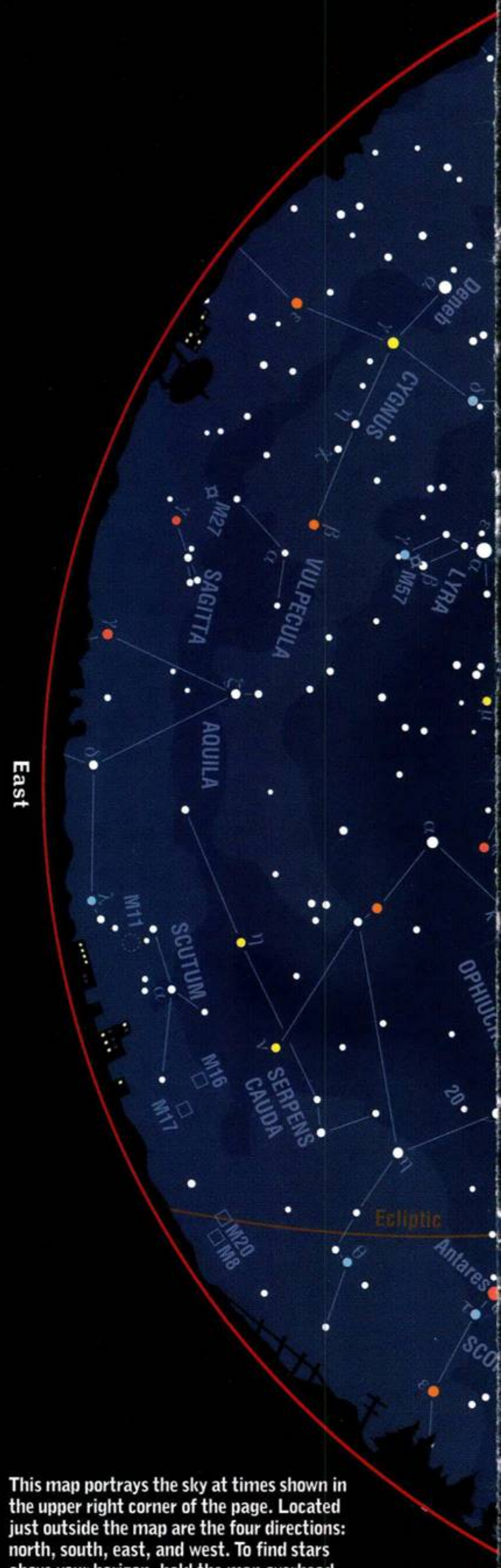
25 The moon passes 1.5° south of Uranus, 2 A.M. EDT
Asteroid Hygiea is at opposition, 2 A.M. EDT
Uranus is stationary, 11 A.M. EDT

26 Last quarter moon is at 7:55 A.M. EDT

31 Jupiter passes 1.2° north of Saturn, 6 A.M. EDT
The moon passes 3° south of Saturn, midnight EDT



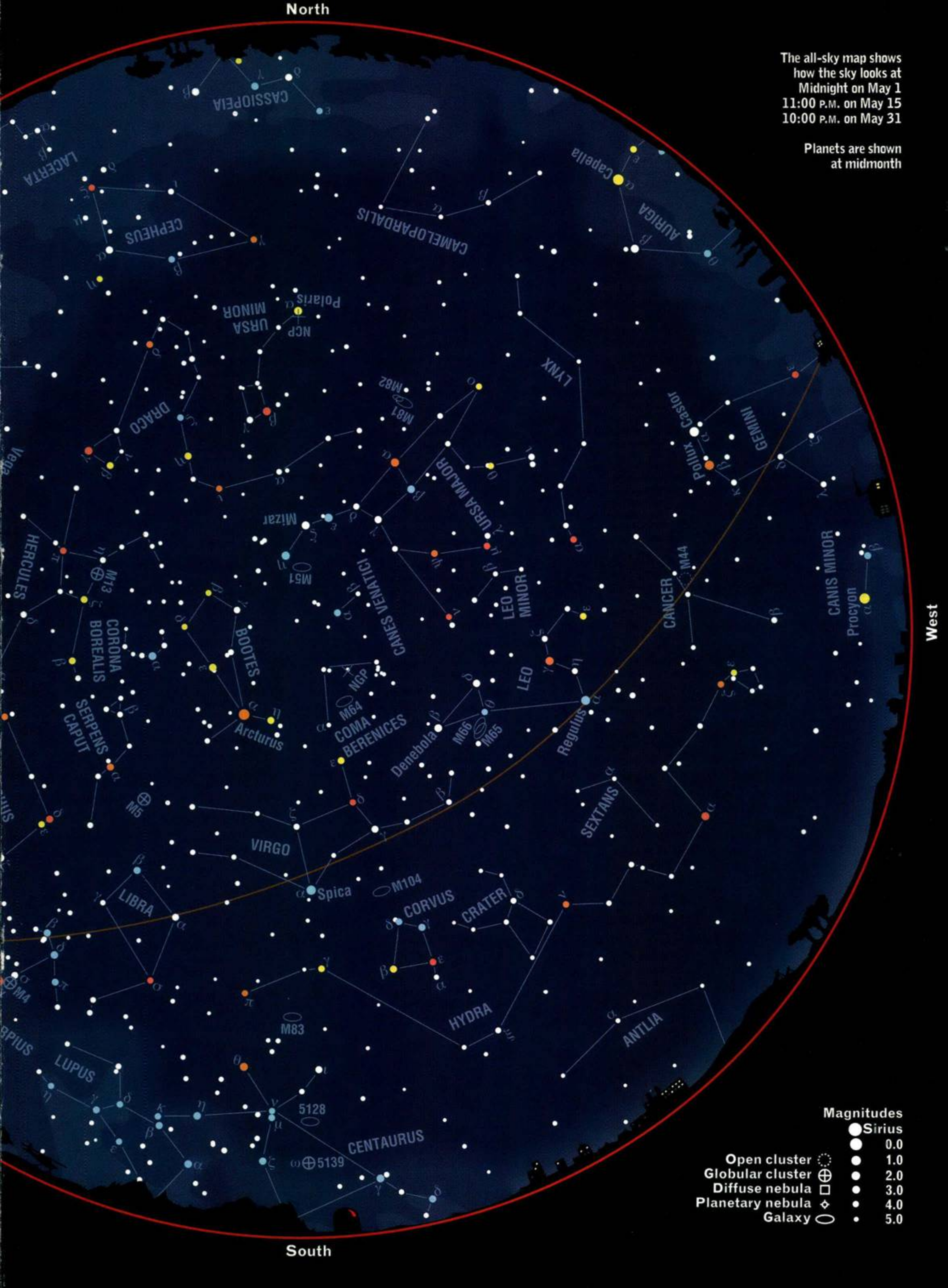
Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			



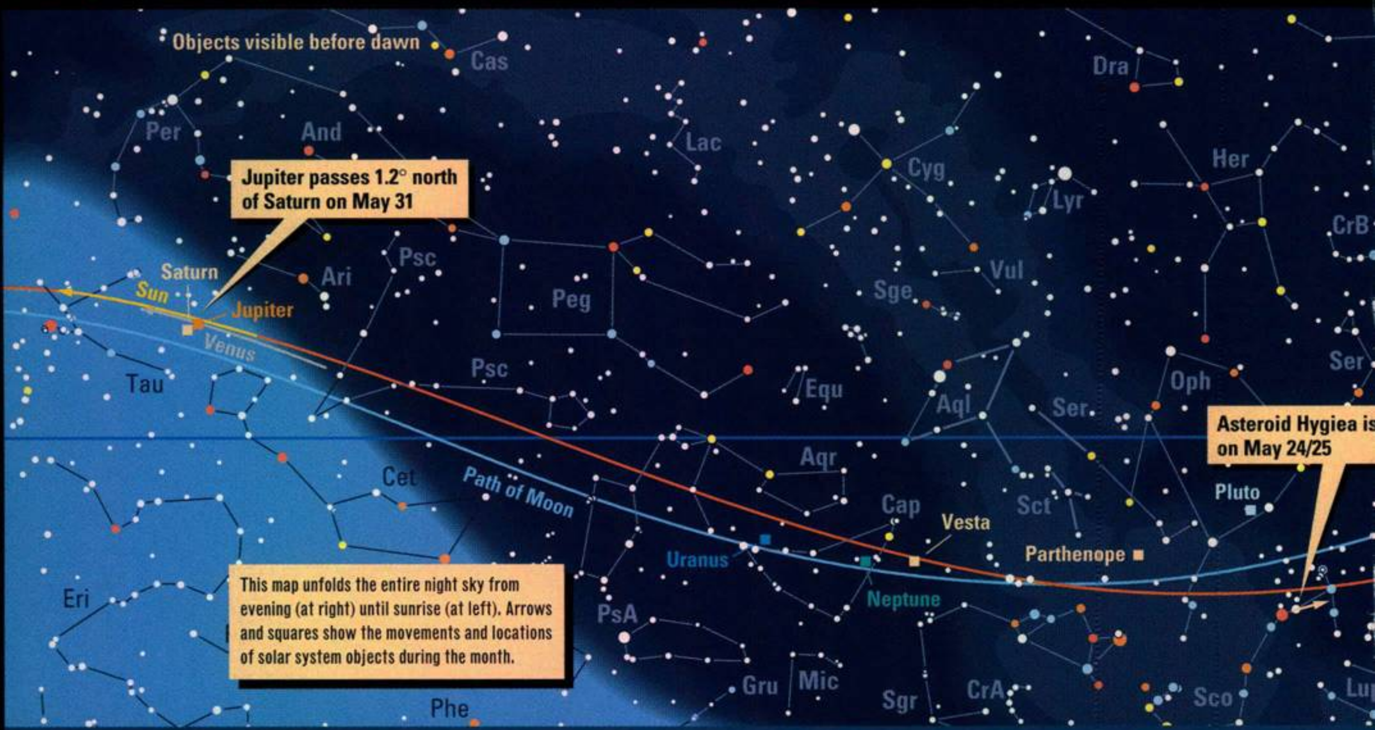
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

The all-sky map shows
how the sky looks at
Midnight on May 1
11:00 P.M. on May 15
10:00 P.M. on May 31

Planets are shown
at midmonth


North
South
West
CASSIOPEIA
LACERTA
CEPHEUS
CAMELOPARDALIS
Capella
AURIGA
Polaris
NCP
URSA MINOR
DRACO
Vega
LYNX
M82
M81
Castor
Pollux
GEMINI
URSA MAJOR
Mizar
M51
HERCULES
M13
CANES VENATICI
LEO MINOR
M44
CANCER
CANIS MINOR
Procyon
CORONA BOREALIS
BOOTES
NGP
M64
COMA BERENICES
LEO
Regulus
Arcturus
SERPENS CAPUT
Denebola
M66
M65
M5
SEXTANS
VIRGO
Spica
M104
LIBRA
CORVUS
CRATER
M4
M83
HYDRA
ANTLIA
SCORPIUS
LUPUS
5128
CENTAURUS
5139
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS

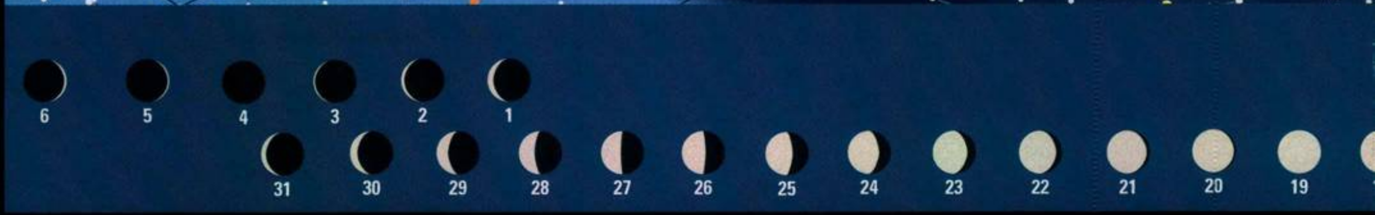


Objects visible before dawn
Cas
Dra
Per
And
Lac
Cyg
Her
Lyr
CrB
Psc
Ari
Saturn
Sun
Jupiter
Venus
Peg
Sge
Vul
Tau
Psc
Equ
Aql
Ser
Oph
Ser
Cet
Path of Moon
Aqr
Cap
Vesta
Sct
Pluto
Eri
Uranus
Neptune
Parthenope
PsA
Gru
Mic
Sgr
CrA
Sco
Lup
Phe

Jupiter passes 1.2° north of Saturn on May 31

Asteroid Hygiea is on May 24/25

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

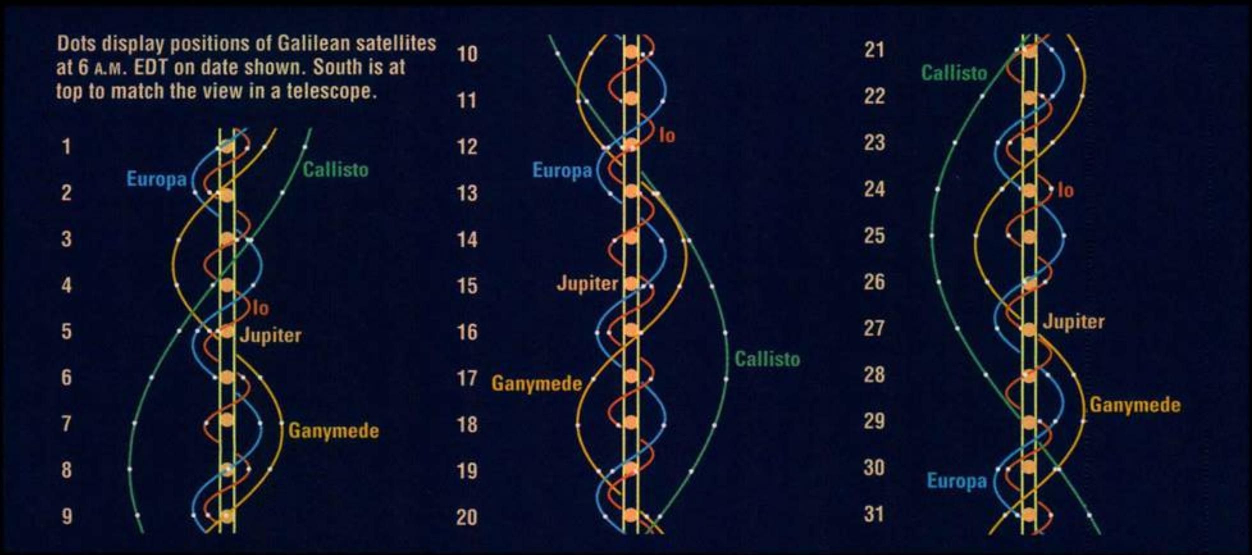


6
5
4
3
2
1
31
30
29
28
27
26
25
24
23
22
21
20
19

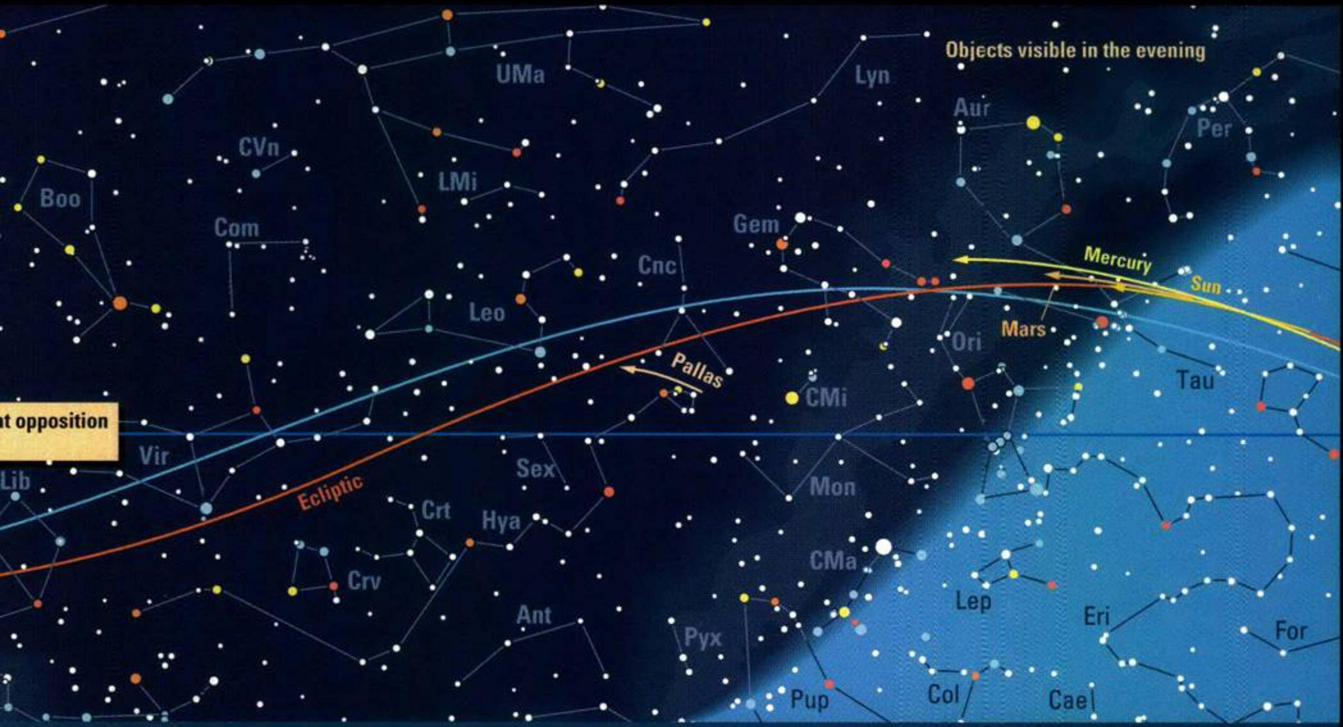
10"
S
W
E
N

PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPITER
Date	May 1	May 31	May 1	May 1	May 31
Magnitude	–1.2	–0.2	–3.9	1.5	–2.0
Angular Size	5.2"	6.7"	9.9"	3.8"	33.1"
Illumination	94%	58%	98%	99%	100%
Distance (AU) from Earth	1.304	1.005	1.688	2.452	5.954
Distance (AU) from Sun	0.350	0.377	0.726	1.518	4.991
Right Ascension (2000.0)	1h59.9m	6h05.5m	1h53.0m	3h42.7m	3h24.4m
Declination (2000.0)	10°49'	25°37'	10°13'	20°06'	17°46'

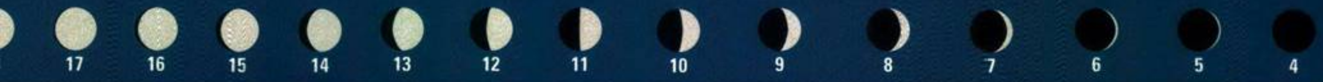
JUPITER'S MOONS

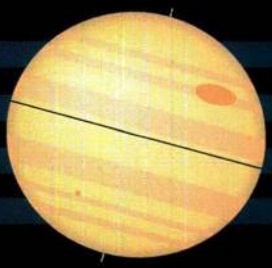


Dots display positions of Galilean satellites at 6 A.M. EDT on date shown. South is at top to match the view in a telescope.


Objects visible in the evening
UMa
Lyn
Aur
Per
CVn
LMi
Boo
Com
Gem
Cnc
Mercury
Sun
Leo
Mars
Ori
Pallas
Tau
CMi
at opposition
Vir
Sex
Lib
Mon
Ecliptic
Crt
Hya
CMa
Crv
Lep
Eri
Ant
For
Pyx
Pup
Col
Cae

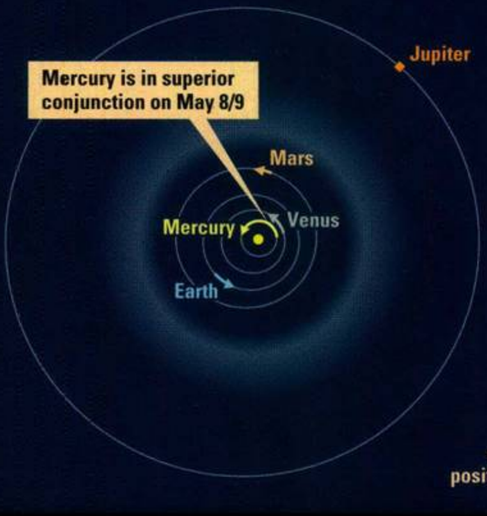
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.


17
16
15
14
13
12
11
10
9
8
7
6
5
4



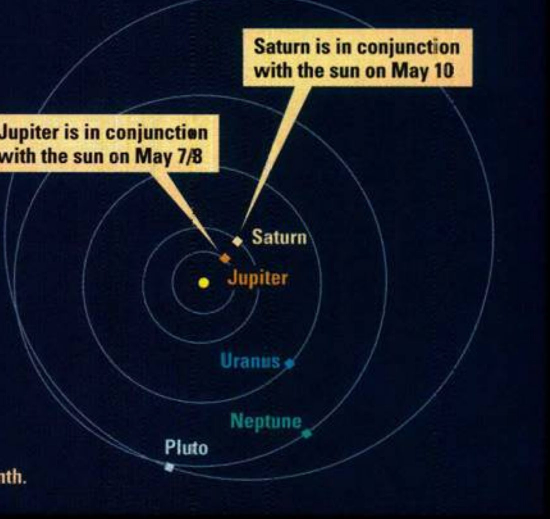
SATURN	URANUS	NEPTUNE	PLUTO
May 31	May 15	May 15	May 15
0.2	5.8	7.9	13.7
16.4"	3.6"	2.3"	0.1"
100%	100%	100%	100%
10.118	19.846	29.789	29.317
9.153	19.937	30.116	30.264
3h24.6m	21h33.6m	20h35.6m	16h48.1m
16°36'	−15°14'	−18°25'	−11°00'

THE PLANETS IN THEIR ORBITS


Jupiter
Mars
Mercury
Venus
Earth

Mercury is in superior conjunction on May 8/9

Arrows and dots represent planets' positions during the month.


Saturn
Jupiter
Uranus
Neptune
Pluto

Saturn is in conjunction with the sun on May 10

Jupiter is in conjunction with the sun on May 7/8

FIRST VIEWS: Star Clusters M44 and M67

Star clusters, a favorite type of deep-sky object, present no end in variation, from bright and splashy to faint but rich. The stars are formed from the same cloud of gas and kept together by gravity. M44 and M67 are clusters that appear close together in the sky and can be viewed from a city.

Once the first humans befriended the starry skies, they noticed a strange cloudlike glow sitting between the bright stars Regulus and Castor in Cancer the Crab. No one knew for sure what it was until Galileo turned a new device known as the telescope skyward and discovered the first open star cluster.

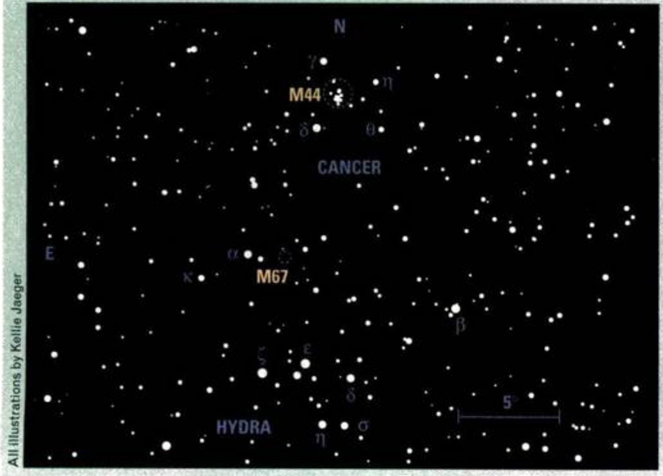
This 3rd-magnitude cluster (M44) has the name Praesepe in Latin, which means "manger." We now refer to it as the Beehive Cluster. Binoculars are the tool of choice for viewing its swarm of stars. When you use a telescope, you miss half the spectacle and lose the perspective of seeing the whole cluster against sparse surroundings.

The Beehive is one of the closest clusters to the solar system, lying only 500 light-years away, but farther than the Pleiades or Hyades. Astronomers have determined its age as 660 million years.

In contrast, the age estimate for M67 is 3.2 billion years, about one-fifth the age of the universe. It lies five times farther away than M44 at some 2,500 light-years. M67 was discovered by a contemporary of Charles Messier, the German observer Johann Koehler, in the 1770s.

M67 is an easy target for binoculars under country skies, but from the city, you'll have to hop 6° north from the "top left" of Hydra's head. Immediately you will notice that most of M67's stars are of similar brightness, 10th to 11th magnitude, and fill out a near-perfect circle 15' across. More than 300 stars have been recognized as belonging to the cluster.

M44 by Alan Dyer



M67 by David Ratledge

All illustrations by Kellie Jaeger

see Cygnus the Swan rising, carrying the summer Milky Way with it. For a few hours, the entire Milky Way appears to lay along the horizon — a sight only visible from the darkest observing locations. Dust and gas in the spiral arms of the Milky Way Galaxy block our view of the universe beyond. During the few hours of late springtime evenings, it's as if the curtain is being pulled aside and the magic of exploring the universe full of galaxies is yours. Our view at night is directly up and away from the galactic plane and out into deep space.

The spring sky is relatively sparse in stars except for three bright notables. Gemlike Arcturus shimmers all night as a resplendent orange beacon in Boötes the Herdsman. The sparkling diamond of Spica in Virgo competes for attention, though it's not as high above the southern horizon as Arcturus. Somewhat farther west lies Regulus, in the constellation of Leo the Lion. Both Spica and Regulus can be occulted by the moon since they lie close enough to the ecliptic to get in our satellite's path. Unfortunately, no such events occur this year. In fact, you'll have to wait until 2005 for the next 1st-magnitude star to be occulted by the moon, when a series of events involving Antares (in Scorpius) takes place.

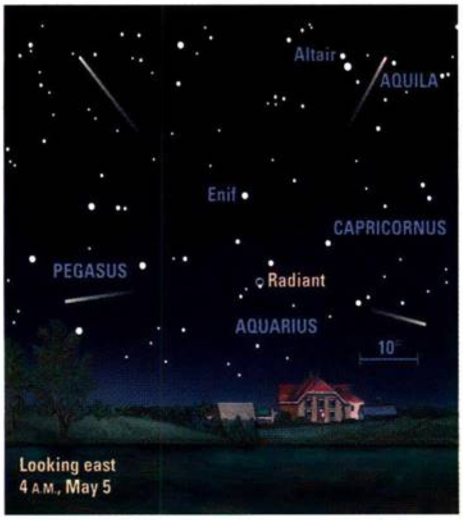
Arcturus, Spica, and Regulus border the fascinating region of sky that is our deep window to the universe. In the direction of the constellations Boötes, Virgo, and Leo, light from galaxies millions of light-years away can reach us relatively unhindered by the intervening gas and dust of the Milky Way. Even so, light from that far away is pretty faint. The familiar law that causes light to dim by a factor of two as the distance doubles really comes into effect here. This inverse-square law diminishes the brightness of any object, but in a predictable fashion. It's this law that allows us to calculate the distance to astronomical objects.

To detect the dim light emitted by galaxies millions of years ago requires a careful method. You need long-exposure photographs or imaging with a CCD camera to produce views such as those depicted in magazines and books. Search for the brighter members first. One galaxy off the beaten track but bright and easy to find is the Sombrero Galaxy, M104. It lies at the same declination as Spica, but farther west. Turn your polar-aligned scope to Spica — which lies at a right ascension of 13h25.2m and declination –11°10' (epoch 2000.0). M104 lies at R.A. 12h40.0m and Dec. –11°37'. Move your telescope due west of Spica by 45 minutes of R.A., or about 11°, using setting circles as a guide. Next, scan from east to west to find M104 in a low-power field of view. M104 is a large spiral galaxy almost edge on to us and sports one of the finest dust lanes visible in amateur scopes. The Sombrero lies about 55 million light-years from Earth at the southern end of the large Virgo supercluster of galaxies.

Eta Aquarids Meteor Max

What could be better than spending a mild, moonless morning under the stars, watching Halley's children streak across the sky?

Dust emitted from Halley's Comet long ago still orbits the sun, and some of it crosses Earth's orbit. We reach one of those intersections in early May. (The other one occurs in mid-October.) Our relative impact speed of 40 miles per second (66 km/sec) lets dust quickly ionize high in our atmosphere, producing the flashes of light we see as meteors.



Looking east
4 A.M., May 5

Peaking on the weekend of the 5th, the Eta Aquarid shower produces about 15 swift meteors per hour under a dark sky. They appear to radiate from the constellation Aquarius near the star Eta (η). Because Aquarius rises in the southeast just after midnight, you might want to grab a nap ahead of time and set your alarm so you don't fall asleep counting meteors. Or retire early and then get up before the sun. For optimal viewing look straight overhead.

The Eta Aquarids remain popular because a fair percentage leave glowing trains. Use binoculars to watch the faintly glowing trails twist slowly in the upper-level atmospheric winds.

The light you see is the meteor; the chunk of debris that produces it is a meteoroid; and any material that reaches Earth is known as a meteorite.

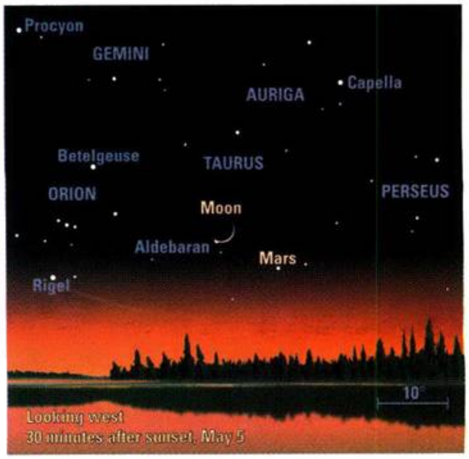
Mars the Valiant

Mars is still not ready to surrender. Now, more than a year since its brilliant command of the spring 1999 sky, Mars is still just visible. Huddled low in sunset's twilight colors, the diminutive God of War glows a feeble magnitude 1.5, revealing itself to a binocular search.

Chances are the first star you'll see low in the northwest is the similarly colored Aldebaran, shining slightly brighter at magnitude 1.0. Mars is one and a half to two binocular fields to the right and a bit lower. If you wait until a full hour after sunset early in the month, you can spy the beautiful Pleiades sharing the sky just off to Mars's right.

Mars becomes increasingly difficult to spot as the days tick by. Is it still possible to see when the much brighter Mercury at magnitude –1.2 soars close to Mars's upper right on the 18th? (See "Mercury's Spring Skip," page 71.)

Keep an eye out on the evening of the 5th as the thin crescent moon slides only 1° away from Aldebaran. If you live in the southern states, try for the young moon on the previous night, the 4th, when it will be only 20 hours old (23 hours on the west coast). Farther north, the sun-moon line is closer to the horizon, making the young moon more difficult to find behind buildings and in the horizon's glow.



Looking west
30 minutes after sunset, May 5

The Ice Mound Cometh

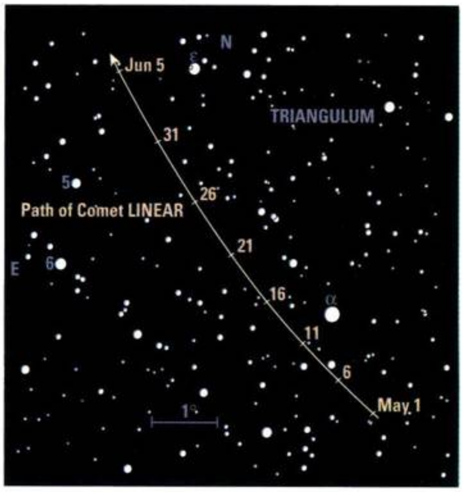
Barring any surprise, which we're always hoping for, Comet LINEAR 1999 S4 will be the brightest one of the year. Astronomers believe it will peak in July around 4th magnitude, making it visible to the naked eye.

It's always fascinating to watch a comet in its early stages. By the very end of May, Comet LINEAR will have climbed low into the predawn sky in Triangulum, glowing perhaps brighter than 10th magnitude. Before then it's close to the sun and suffers from interfering moonlight.

An 8- or 10-inch telescope at low power will show you a small, galaxylike fuzzball. Can you see a sharp core? If so, this is not the actual nucleus of the comet, but the inner envelope of gas and dust, or coma.

Large scope owners who live in the south and want a considerable challenge might just be able to pick it off at the begining of the month.

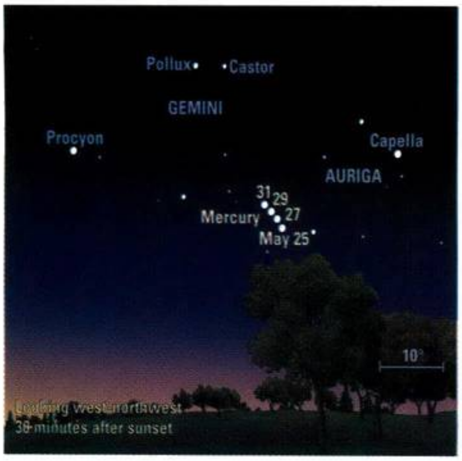
Unlike the names of many other famous comets, the name LINEAR does not derive from a person who made the discovery, but rather a team with a robotic telescope and computer system at MIT. LINEAR stands for Lincoln Laboratory Near Earth Asteroid Research. The comets they discover are a by-product of their true goal: asteroids. You can learn more about this successful program at http://www.ll.mit.edu/LINEAR/ or read about it in our April 1999 issue.



Mercury's Spring Skip

The best Mercury apparition of the year starts in the last week of May for northern observers. You can't miss it if you know when and where to look.

At about 8 P.M., scan one binocular field above the point where the sun had set an hour earlier. At magnitude –0.5, the yellow-orange speck will be noticeable near the horizon. Farther north, the sixth brightest star in the sky, Capella, stands much higher up. If you hold out your arm fully extended, Capella should be two fist-widths above the horizon, compared to Mercury's height of only half a fist-width.



By month's end, Mercury has faded to magnitude 0 but should be somewhat easier to spot because it has climbed away from the horizon's glow.

It reaches its maximum height in the first days of June, perfect for pointing the way to a very thin crescent moon on the evening of the 3rd. The moon lies a binocular field below Mercury.

Capture a picture of Mercury as it tries to break free from the horizon's glare. Photographers attempting to grab a portrait of Mercury often lose its glimmer in the light of the departing sun. Find a location where any light pollution from a city is behind you, so it can't possibly add to washing out your image.

Virgo is the second largest constellation in the sky and home to most of the galaxies visible during any one night. It is surpassed in size only by the serpentine Hydra the Water Snake. Hydra stretches about 100° — spanning from a dim line of stars south of Spica west to the serpent's head, a compact little grouping of six 4th-magnitude stars just south of the Beehive Cluster (M44) in Cancer the Crab. The brightest star in Hydra is 2nd-magnitude Alpha (α) Hydrae, or Alphard, a name that means "The Solitary One." Alphard lies 20° south of Regulus.

Another wonderful galaxy with an interesting dust feature, this time near its center, creates the appearance of a black eye. The Blackeye Galaxy, or M64 (R.A. 12h56.7m, Dec. 21°41'), discovered by Johann Bode in 1779, shines at magnitude 8.5. M64 lies north of Virgo and south of the Big Dipper in an attractive but faint grouping called Coma Berenices. Also referred to as the Sleeping Beauty Galaxy, the galaxy's form has an odd feature — the inner disk rotates in one direction while the outer disk rotates in the opposite direction. The interaction between these two disks has created a region of new star formation, near the visible dust lane.

Yet another fine example of dust lanes can be found 6° northwest of M64. The great edge-on spiral galaxy NGC 4565 (R.A. 12h36.3m, Dec. 25°59') appears as a pencil-like smudge of light a quarter of a degree long and just 2' wide. Try spotting the prominent dust lane that bisects the galaxy. A similar dust band lies in the plane of the Milky Way and prevents us from seeing many galaxies at times of the year when the Milky Way is above the horizon.

Many dim galaxies lie within reach of amateur scopes, but they are not the only challenging objects visible this month. **Pluto** reaches its peak magnitude for the year on May 31. Because the distant planet glows feebly at magnitude 13.7, just seeing Pluto is an achievement. After midnight during early May is the best time to search for Pluto, while the moon stays below the horizon. The dim planet lies less than 1° away from the magnitude 4.6 star 20 Ophiuchi, which itself is just 3° east of the brighter Zeta (ζ) Ophiuchi. (See "Pluto Hunting Season," page 72.)

By 3 A.M. local time, **Uranus** and **Neptune** are above the southeastern horizon. Both are visible using binoculars among the faint stars of Capricornus the Sea Goat. Dimmer Neptune rises near midnight and lies in the eastern part of the constellation 1.6° east-southeast of the magnitude 4.8 star Rho (ρ) Capricorni. Neptune shines at magnitude 7.9, just visible in binoculars. Its disk, 2" in diameter, requires a telescope to detect.

The minor planet Vesta lurks in the same region as Neptune. Moving eastward against the stars of Sagittarius, it reaches a point 3.1° north of the globular cluster M75 on May 15 and then crosses into Capricornus. Vesta is the brightest asteroid visible this month, glowing at magnitude 6.6 and brightening as it approaches opposition in July, when it will appear brighter than Uranus, at

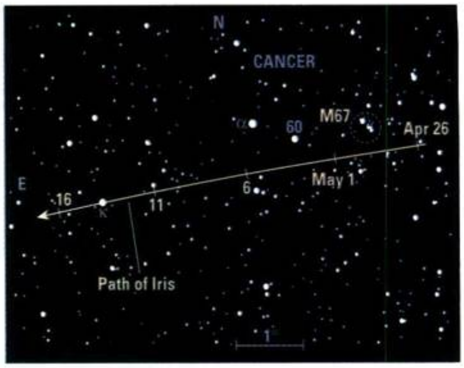
Iris Crawls over the Crab

Asteroid 7 Iris floats in front of Cancer the Crab in the last week of April. The star cluster M67 (see FIRST VIEWS: Star Clusters M44 and M67, page 69) provides a nice backdrop for Iris, before the space rock appears to make a beeline toward the star Kappa (κ) Cancri on the 14th.

Discovered by John Russell Hind on August 13, 1847, this 125-mile-wide (200-km) mountain is named in honor of the Goddess of the Rainbow.

On April 28th, you can find Iris only 30', one moonwidth, southwest of M67. The asteroid shines at a similar brightness to the cluster stars.

Iris lies only 3' east of Kappa on the 14th. You should see it continuing to shift eastward during the evening. At magnitude 10.5, Iris is similar in brightness to three field stars east of Kappa, perfect for watching it move over a three-hour period. Use a 4-inch scope or larger to follow it from one night to the next.

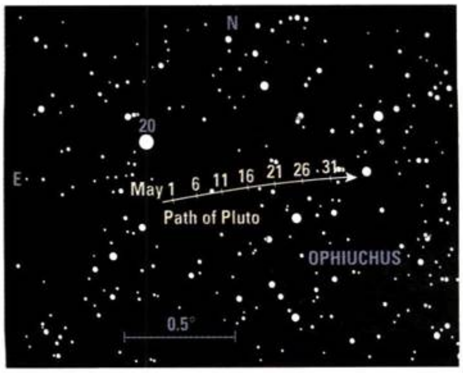


Iris belongs to the S-class of asteroids, which means it is composed mainly of silicate minerals. This class is relatively common for asteroids that reside in the inner portion of the main asteroid belt. Eunomia and Amphitrite are other well-known members of this class.

Pluto Hunting Season

If it's spring, it must be time to go to a dark site and ferret out the solar system's most distant planet. Fortunately, there are some easy skyposts that point the way.

First, you'll need to try in the first or last week of May, when the moon is out of the sky. Wait until at least midnight, to let the southern sky swing above the horizon's haze. Then find the three equally spaced bright stars forming the base of Ophiuchus and point your 8-inch or larger scope at the middle one. Experienced observers can spot Pluto in a 4-inch scope if they really want a challenge.



Fortunately, just off to the east lies 20 Ophiuchi (also see the map on pages 67 and 68), a 4.6-magnitude star that will be a fine starting point. Unfortunately, Pluto lies in the same low-power field to the southwest. You'll need to shift your scope down a bit to prevent 20 Ophiuchi's glare from blasting your dark adaptation.

Use the chart and slowly increase the magnification past 150x in order to find the magnitude 13.7 Pluto relative to the fainter stars in the area. Don't give up if you can't see it immediately. Many first timers take 30 minutes to be confident of their sighting. Each time you use a flashlight, even a dim one, to check the chart, you temporarily lose your ability to see faint objects in the dark. It really pays to memorize miniature star patterns that point the way.

Follow the advice of advanced observers. Use a dark cloth over your head to cut out stray light and don't hold your breath because your brain needs oxygen. If you use a star diagonal, photocopy the chart, flip it over, and shine your flashlight up from underneath, to match the reversed orientation in your eyepiece.

magnitude 5.4. Binoculars are sufficient to track its progress against the starry background.

Uranus rises an hour after Neptune. At magnitude 5.7, it's easy to see in binoculars, lying 2° northwest of Gamma (γ) Capricorni, the magnitude 3.8 star near the northeast corner of Capricornus. Telescopes reveal the greenish disk almost 4" in diameter.

Following the grand conjunction of the planets, Jupiter and Saturn emerge from the sun's glow, and Venus sinks toward conjunction with the sun. On May 17, Venus and Jupiter have their closest conjunction since 1892, when they pass just 42" apart at 6:30 A.M. EDT. This occurs in daylight just 6° from the blinding sun, so only try viewing this event if you are well practiced at working near the sun. Remember that one mistake in pointing could result in permanent blindness if the sun inadvertently enters the field of view. (See "OBSERVER'S CHALLENGE: Venus and Jupiter Graze," page 73.)

Another conjunction occurs toward the end of May when, for a period of a few days, Jupiter and Saturn appear together in the same low-power field of view. Their closest point occurs on May 28, when only 1.1° separate them. By the end of the month the pair lie 15° away from the sun, so they remain in bright twilight, but this rare appearance is worth a try. Saturn is practically double the distance from us as Jupiter is.

Finally, this year's Eta Aquarid meteor shower should put on a good show because a new moon occurs on May 5, a day before the peak. The Eta Aquarids remain active for about three or four days either side of the peak date. However, the radiant rises only an hour or two before dawn. This geometry means North American observers have the chance to view meteors that skim our atmosphere, resulting in considerable path lengths. Make sure to watch out for the occasional fireball. This splash of solar system debris into our atmosphere has the significance of being one of the two annual meteor showers associated with Halley's Comet, the other shower is October's Orionids. (See "Eta Aquarids Meteor Max," page 70.) ■

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

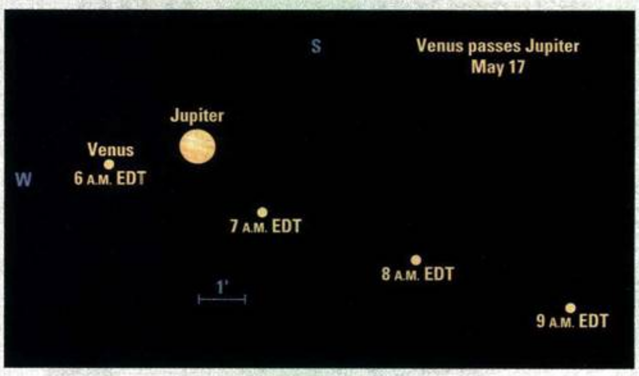
OBSERVER'S CHALLENGE: Venus and Jupiter Graze

Lucky Europeans have the chance to see Venus lie less than one Jupiter-diameter from the mighty gas giant. Late in the morning of the 17th, Venus will scoot past Jupiter almost fast enough to see orbital motion in real time. When the close pair rises high enough for North Americans, they will be only 4' apart, still close enough to fit in your highest power eyepiece. Venus plays a mock Galilean satellite, and in a dark sky it would appear to be positioned between Io and Europa.

The real trick is not just that it happens in morning's light, but that they lie so close to the sun, only 7° away. Is it worth the effort? Every ounce. To take the challenge, you'll need one of those deep-blue-sky days. The slightest haze or cirrus clouds will wash out any chance of seeing this event. If you live in the southern states, you may get a chance to see them just above the horizon in the few minutes before sunrise.

This sort of observing requires a warning: Make sure that sunlight does not enter your telescope. An extra set of hands is the best defense. Hold a screen just off to the side, to put the front of the telescope in shadow.

If your scope is aligned and you have setting circles, then it is a straightforward jump to Venus and Jupiter. Cap the front of the scope and finder, and then try to make the scope's shadow as small as possible. Now use the setting circles to offset the scope 2.5° south (down), and 26.8 minutes of R.A. west (right).



Dobsonian owners can try different offset methods. The previous night, set your scope on Arcturus and shift it 2.2° south. Note the time. Twelve hours and 54 minutes later, on the morning of the 17th, Venus and Jupiter should lie within a 1° field of view (unless wind has moved the scope). The second method involves using a planetarium computer program to get the following specifics for you. Sometime around 11:30 A.M., the pair will lie exactly west of the sun, that is, at the same altitude in the sky. Cover the scope as noted above to start at the sun, then shift 7° in azimuth to the right, using your best guess.

Whatever method you choose, use your lowest power to locate them. Remember to leave your telescope focused from a previous night to avoid an increased challenge of searching for a faint, out-of-focus image. Jupiter will remain a ghostly disk compared to the bright but small, round Venus, which will be lying on the sunward side of Jupiter.

An additional challenge follows during the last week of May. Saturn lies a bit more than 1° south of Jupiter, but fortunately the sun is farther away, about 14°. Even if smog or clouds aren't present, Saturn may not be visible at all, but why not give it a try?

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ASTRONOMY BOOKS

The Deep Sky: An Introduction

By Philip S. Harrington Here is the perfect reference for anyone, who owns a telescope or a pair of binoculars but doesn't know what to look for amid the constellations. It explains how to find double and multiple stars, variable stars, open and gobular clusters, nebulae, and galaxies — what you'll see when you do.Includes 36 full-page sky charts; equipment, books, and software suggestions; sketches of how deep-sky objects look through a small telescope; and more than 100 black & white photographs. 272 pages.

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Déjà Blue?

Bushnell's new Voyager telescope has the same look as the Astroscan. But does its performance stack up?

by Glenn F. Chaple, Jr.

WHEN I FIRST SAW BUSHNELL'S NEW ADDITION TO ITS VOYAGER LINE of family telescopes, it reminded me of a blue Astroscan. The Astroscan is Edmund Scientific's classic fire-engine-red, rich-field reflector (see "The Little Scope that Could," May 1998). It has an unmistakable "tin can jutting out of a bowling ball" appearance. The Voyager 100x4.5-inch is Bushnell's look-a-like answer to the Astroscan. It too is designed for beginners seeking a low-cost, easy-to-use, maintenance-free telescope, as well as veterans in search of a high-performance portable second scope.

Bushnell has been a supplier of optical goods including telescopes, binoculars, and riflescopes since 1947. Early Bushnell telescopes were typically small in aperture and intended for novice observers. Unfortunately, Bushnell was one of the companies that produced "bargain" telescopes — 60mm refractors that promised super-high power but delivered wobbly mounts and poor images. A merger

Bushnell's compact Voyager 100x4.5-inch telescope has a familiar design. All photos: *Astronomy*/Jim Forbes

BUSHNELL

The Voyager 100x4.5-inch telescope includes two eyepieces, a 27mm Plössl and a 5mm SR.

with Bausch and Lomb in 1992 enhanced Bushnell's image, but the "bargain scope" stigma remained. Product Manager Darin Stephens points out that Bushnell is in the process of phasing out its low-budget refractors while upgrading the quality of the telescopes it continues to market. "We're now moving toward quality affordable telescopes for the novice and advanced observer alike," says Stephens. The Voyager 100x 4.5-inch is part of that movement.

With this new company philosophy, you might ask why Bushnell would manufacture another "Astroscan." Stephens admits an initial reluctance to its production. But the Astroscan's design patent had run out, and he knew that some features could be improved.

For the most part, the Voyager 100x4.5-inch remains pretty Astroscan-ish. It's a Rich-Field Telescope (RFT), intended to produce a low-power, wide-field view. The 4.5-inch (114mm) primary mirror has a 500mm focal length, yielding a focal ratio of 4.4. The diagonal is affixed to an optical window placed at the opening of the tube. The "window" helps keep dust from settling on the primary mirror, creating a relatively maintenance-free instrument. The "bowling ball" part of the design rests in a low friction cradle mount and can be swiveled around in any direction. Since the eyepiece is just 16 inches from the ground when the scope is aimed toward the zenith, you may want to place it on something stable and elevated (the telescope is designed to mount on any standard camera tripod). Budget-minded individuals might consider constructing an Astroscan mount similar to the one described on page 84 of the September 1991 issue.

The two eyepieces included with the Voyager cover a variety of observing situations. A 27mm (18x) Plössl produces wide 2.7° field views that sweep the sky (hence the lack of a finderscope). It provides spectacular views of large-scale objects such as star clusters and nebulae. Close-ups of the moon and planets can be had with the 5mm Symmetrical Ramsden (100x) eyepiece.

The Star Party Test

The Voyager 100x4.5-inch is meant to be user-friendly. No assembly is required. Just remove it from the box, slip an eyepiece into the focuser, and begin your adventure. To test its ease of use, I brought the telescope to a local star party held at an elementary school. I invited the hosting teacher and attending parents to give it a try. Occupied with another telescope, I was unable to offer much assistance, but it didn't matter. Throughout the evening, the teacher or one of the parents would approach me and enthusiastically describe how fantastic the moon, Saturn, or Jupiter looked. The Pleiades (M45) proved to be a revelation to eyes that had only seen it as a dipper-shaped assemblage of naked-eye stars. As the star party drew to a close, I offered to loan the telescope to the teacher for a few weeks. She owned a "bargain" refractor that had given her innumerable headaches. This didn't happen with the Voyager. For the first time, she could enjoy views of the night sky with an easy to operate telescope. "There is no chance," she noted, "that someone will take this telescope out of the box and then abandon it out of frustration." She did encounter some difficulty when switching to high power. Occasionally the target would fail to come into view, necessitating a return to low power.

The Backyard Test

My own trials showed the Voyager 100x4.5-inch to be a good performer. Since it lacks a finderscope, locating sky objects requires a little practice and patience. I approximated the location of each target by visually aligning it with the top of the scope's bowling ball base and the bottom of the focuser. A low-power sweep usually brought the object into view in a minute or two.

The telescope produced nice panoramic views of large showpiece objects — notably the Andromeda Galaxy (M31), the Double Cluster (NGC 869 and NGC 884), and the Orion Nebula (M42). However, I encountered a troubling "ghost" when viewing bright Jupiter. The 5mm eyepiece also revealed some chromatic distortions — Jupiter's disk was bracketed by red on one side and blue on another. Nebulous objects weren't as affected. The Orion Nebula was a grand high-power sight, revealing numerous luminous wisps.

Its compact design, light weight, and handy carrying strap make the Voyager 100x4.5-inch a good choice for observers on the move.

Bushnell Voyager 100x4.5-inch model #78-2010

CLEAR APERTURE: 114mm
FOCAL LENGTH: 500mm
FOCAL RATIO: 4.4
LENGTH OF TUBE: 18 inches
FOCUSER: 1.25-inch rack and pinion
INCLUDED EYEPIECES: 27mm Plössl (18x) and 5mm SR (100x)
FINDER: none (one is on the drawing board)
SECONDARY SIZE: 40mm
SECONDARY OBSTRUCTION: (by diameter) 35%, (by area) 12%
TOTAL TELESCOPE WEIGHT: 12 lbs
EYEPIECE HEIGHT AT ZENITH: 16 inches
RETAIL PRICE: suggested $330
OPTIONAL ACCESSORIES:
9mm and 25mm Kellner eyepieces (56x) $45.95
2x Barlow lens $54.95
Tripod $330
Camera adapter $330

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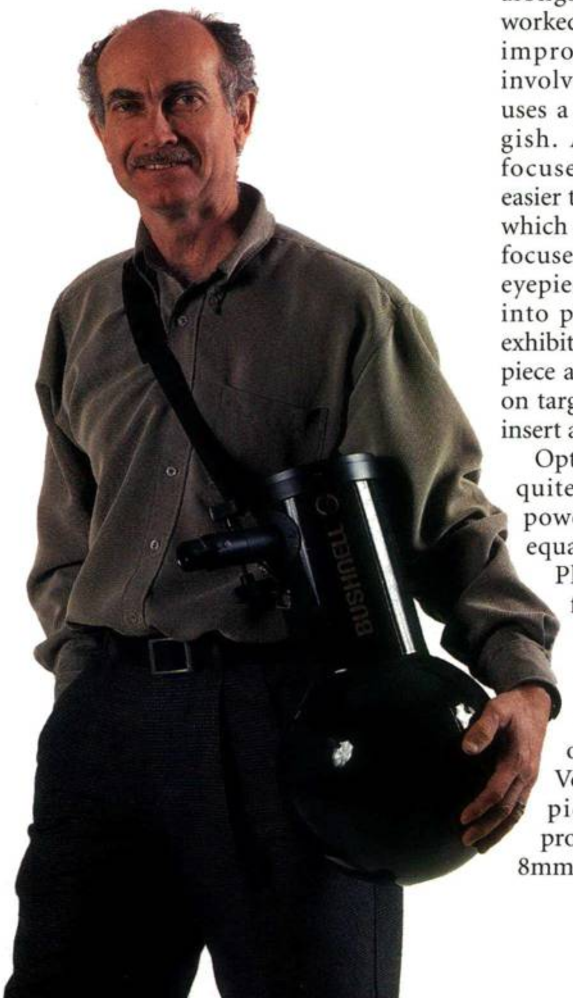
The Voyager also proved to be a capable workhorse. In a project monitoring the brightness changes of an eclipsing variable star, I used the scope to make observations every ten minutes over a two-hour period centered on the star's predicted eclipse time. Even without a finderscope, I was able to quickly find the star at each observation (it helped that my target was a short hop from Altair). Voyager's wide, low-power field was perfect for the job. It nicely encompassed the variable and surrounding comparison stars.

But the observing run was not trouble free. In the cold, damp, late autumn air, the optical window began to fog. I remedied the situation by bringing the scope indoors, where the dew evaporated. This tactic wouldn't have been possible with a larger, nonportable scope. A return outside to colder temperatures didn't appear to cause stability problems with the optics, and I successfully completed my observations.

Side by Side

How does the Voyager 100x4.5-inch stack up against its legendary predecessor? To find out, I placed it alongside my trusty Astroscan and worked them head-to-head. One of the improvements Bushnell has added involves the focuser. The Astroscan uses a rubber roller that can be sluggish. A standard rack-and-pinion focuser makes Bushnell's telescope easier to use. Another plus is the ease at which eyepieces can be changed. The focuser is just wide enough to allow eyepieces to be removed or dropped into place with ease. My Astroscan exhibits some friction between the eyepiece and holder. To keep the telescope on target, I have to cradle the tube as I insert a new eyepiece.



Optically, the Voyager I tested didn't quite match the Astroscan. At low power, the two scopes were nearly equal. The Voyager, with its 27mm Plössl eyepiece, produced wide-field images that compared favorably with those generated by the Astroscan and its 28mm RKE eyepiece. At higher magnifications the Astroscan won out. Star images viewed with Voyager's 5mm high power eyepiece weren't as crisp as those produced by the Astroscan with an 8mm RKE eyepiece. This high-power discrepancy was most notable when I turned both scopes on the Trapezium — the famous multiple star in the heart of the Orion Nebula. The Astroscan with an 8mm RKE resolved the four primary members of this system. Voyager and its 5mm eyepiece showed only three. Placing the 8mm RKE in the Voyager improved the overall image quality, but Trapezium's fourth member was still a no-show.

Traditionalists might quibble about Voyager's lack of originality. But it's good to have choices, and the Bushnell version provides just that. It may not match the optical excellence of its counterpart, but it's definitely not a "junk" scope. Some outlets retail the Voyager 100x4.5-inch for under $200, nearly $150 less than an Astroscan. That's a serious consideration for the budget-minded beginner. Bushnell has produced a "bargain" telescope that is a true bargain. ▣

Glenn Chaple, a teacher living in Townsend, Massachusetts, is a frequent contributor to Astronomy. *His latest review was "A Gem for All Seasons," May 1999.*

Stars above the Sandhills

The Nebraska Star Party offers majestic views to beginning and seasoned astronomers from around the globe.

by Nancy Hendrickson

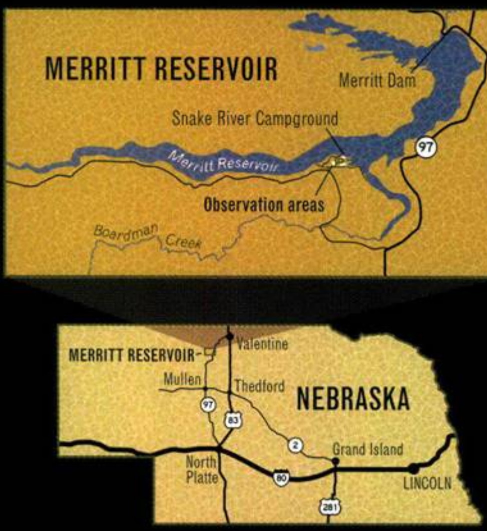
Here in Cherry County, Nebraska, the skies are so dark it would take a lifetime to navigate the stars. Here, the streaming band of the Milky Way starts low, flows up through Sagittarius, then flings itself across the broad expanse of sky — as if a stargazer waved her hand and stars poured from her fingertips. Here, the central bulge of our Galaxy is clearly visible, leaving no doubt what island of stars is ours. And here, for some inexplicable geological reason, the skies have remained almost as untouched as the day they were created.

Welcome to the Nebraska Star Party (NSP), an annual gathering that can almost guarantee 7.5- to 8th-magnitude skies for at least a few of the nights during the event, thanks to the pristine area around Valentine, Nebraska. When you're there, take a step back in time to discover that, over millions of years, while mountain ranges rose and vast inland seas came and went, continental shifting lifted the land above an ancient sea level and formed the Great Plains.

Nebraska's open range of Sandhills provides unobstructed viewing and makes a perfect *star party location.* Mark Dahmke

Nebraska Star Party — 2000

The 7th Annual Nebraska Star Party is scheduled for July 29 through August 5, 2000, at Merritt Reservoir. Contact the Prairie Astronomy Club, Inc. — NSP, c/o John Lawler, 4600 Bingham Court, Lincoln, NE 68516; NSP Hotline: (402) 421-7855 (John Lawler); e-mail, NSP@4w.com; website, http://www.4w.com/nsp/. See you there!



Astronomy/ Elisabeth Rowan

And If You Can't Make Nebraska . . .

All stargazers know that light pollution destroys the night sky. Poorly designed and badly aimed lighting fixtures constitute the majority of the problem. Educational efforts sponsored by the International Dark Sky Association (IDA) helped improve some situations.

The IDA helps amateur astronomers find dark sky sites by linking them to Steve Albert's "DarkSky" (http://proxima.astro.Virginia.EDU/~ida/darksky/), a web-based model that helps find the darkest sites nearest observers' homes.

Click on your site from a nighttime map of the United States. "DarkSky" selects and displays the darkest sites within a 60-mile radius. Site listings give approximate zenithal naked-eye-limiting magnitude, distance, longitude, and latitude. The limiting magnitude is approximate and assumes perfect conditions.

For further information, or to join the International Dark Sky Association, contact IDA, 3225 N. First Ave., Tucson, AZ 85719.

Mark Dahmke

Tom Miller's 30-inch Dobsonian telescope is a popular attraction at the Nebraska Star Party site.

As if in some majestic partnership, winds blew from the west, while mighty rivers rushed eastward, carrying silt and depositing sand to form the largest dune system in the Western Hemisphere — the Nebraska Sandhills. Author Mari Sandoz, a Sandhills native, describes it as "a great sea, caught forever in a spell. . . ."

And yet it is a sea of sorts. The 19,000 square miles of Sandhills straddle the Ogallala Aquifer, one of the largest underground water sources in the United States. Between the subsurface water, the rain, and the 700 varieties of grasses, ranchers discovered that the stabilized Sandhills dunes provide for premier cattle grazing. Cows outnumber people by almost 10 to 1, and the need to light the night sky is nil. A glance at any nighttime satellite photo attests to the fact that north central Nebraska is also "Star Party Country."

World-Class Observing

The Nebraska Star Party started in 1994. Prairie Astronomy Club members Tom Miller, John Bruce, and Dave Scherping, back from the Texas Star Party, realized they had a dark-sky paradise in their own backyard. Tom suggested a campground at Merritt Reservoir as the observing site. About 75 people attended that first informal gathering, and since then attendance has grown by as much as 25 percent annually. High in the heart of the Sandhills, the location boasts world-class observing by night and family fun during the day.

In its second year, the Prairie Astronomy Club became NSP's official sponsor, and by NSP-3, the Omaha Astronomical Society came on board as cosponsor. The fourth event drew participants from as far away as Brazil, Belgium, and Hawaii. NSP's reputation was spreading.

Despite threatening weather, NSP-5 went off with a bang. The first two days especially offered perfect viewing skies. For David Knisely, president of the Prairie Astronomy Club, the knockout of the first night was the bright planetary nebula NGC 6543 in Draco, the Cat's Eye Nebula. All the scopes in the field showed its greenish-blue hue, with its central star easily visible even in a 10-inch scope. M27, known as the Dumbbell Nebula, was visible to the naked eye. Barnard's Galaxy was spotted with 10x70mm binoculars, and some of the Messier objects in Sagittarius were almost photographic in appearance.

NSP-6 enjoyed similar success. Formal speeches included those given by Kathy Machin of the Astronomical League Award (neophyte astronomers), Richard Wild (lunar observing), and Bill O'Donnel of the Omaha Astronomical Society (astronomy clubs). Keynote speaker Brian Skiff of Lowell Observatory in Flagstaff, Arizona, talked about the current "edge" of deep-sky observing. To top off the event, the Perseids put on a fine display, with bright meteors leaving short trails at rates that hit 60 per hour.

Beginners Welcome

The Beginner's Field School made its debut at NSP-5 and continued in 1999. The NSP is known as the beginner-friendly star party, thanks to this Field School. No one is left to flounder on his or her own. Beginners test new skills learned that afternoon with an experienced observer at their side in the evening.

Past Nebraska Star Parties have been blessed with good weather. Except for an occasional storm or windy night, observing conditions can be nearly perfect. Objects such as the Veil and North America nebulae are easy targets in nearly every telescope. Globular clusters brazenly show off their colors. And truly dedicated deep-sky observers answer the NSP Observing Challenge, trying their best to pick off the sky's most elusive objects.

NSP's home base, Merritt Reservoir, is a vacation destination for prairie-bound Nebraskans — even those who aren't stargazers. With an 11-mile-long lake and 44 miles of shoreline, families can swim, camp, sail, water ski, or just float in the sun. Fishing records get set and broken at Merritt, with walleye, bass, perch, and catfish among the catches. Surrounded by rolling dunes, their grasses rippling like the ocean they so resemble, the lake offers a welcome retreat from the heat.

A stretch of the Niobrara River flows past Valentine. Named by *Backpacker* magazine as one of the top ten canoeing rivers in America, the river runs free and undammed. Designated a National Scenic River in 1991, the Niobrara's biology is as unique as the Sandhills' geology. In this area, numerous plants reach the limit of their range, with eastern elm and black walnut, northern birch and aspen, and western ponderosa pine and juniper all sharing space. Wildflowers burst with color along the pine-covered hills. Purple vetch, prairie larkspur, and sand verbena, abundant in mid-summer, crowd the gullies.

A sliver of a moon accents sunset at a Nebraska Star Party.

Mark Dahmke

Doug Bell

Beach toys abound as children head for the Merritt Reservoir and a refreshing dip under the hot Nebraska sun.

The 14-mile trip from Valentine to Smith Falls, Nebraska, takes three hours by canoe, or double that by inner tube. No need to rush, though. Born of spring-fed tributaries, the river flows leisurely through sandstone canyons and under old bridges, one of them a railroad trestle towering 150 feet above the river. The railroad bridge is on the Cowboy Trail, a biking, hiking, and equestrian route that's part of the Rails-to-Trails Conservancy.

Avoid afternoon thunderstorms by planning morning activity trips. Lucky visitors may see a buffalo or two where the river runs through the Fort Niobrara Wildlife Refuge. Established in 1912, the refuge provides a safe haven for many of the species that once roamed the plains — elk, white-tailed deer, pronghorn, and more than 200 species of birds.

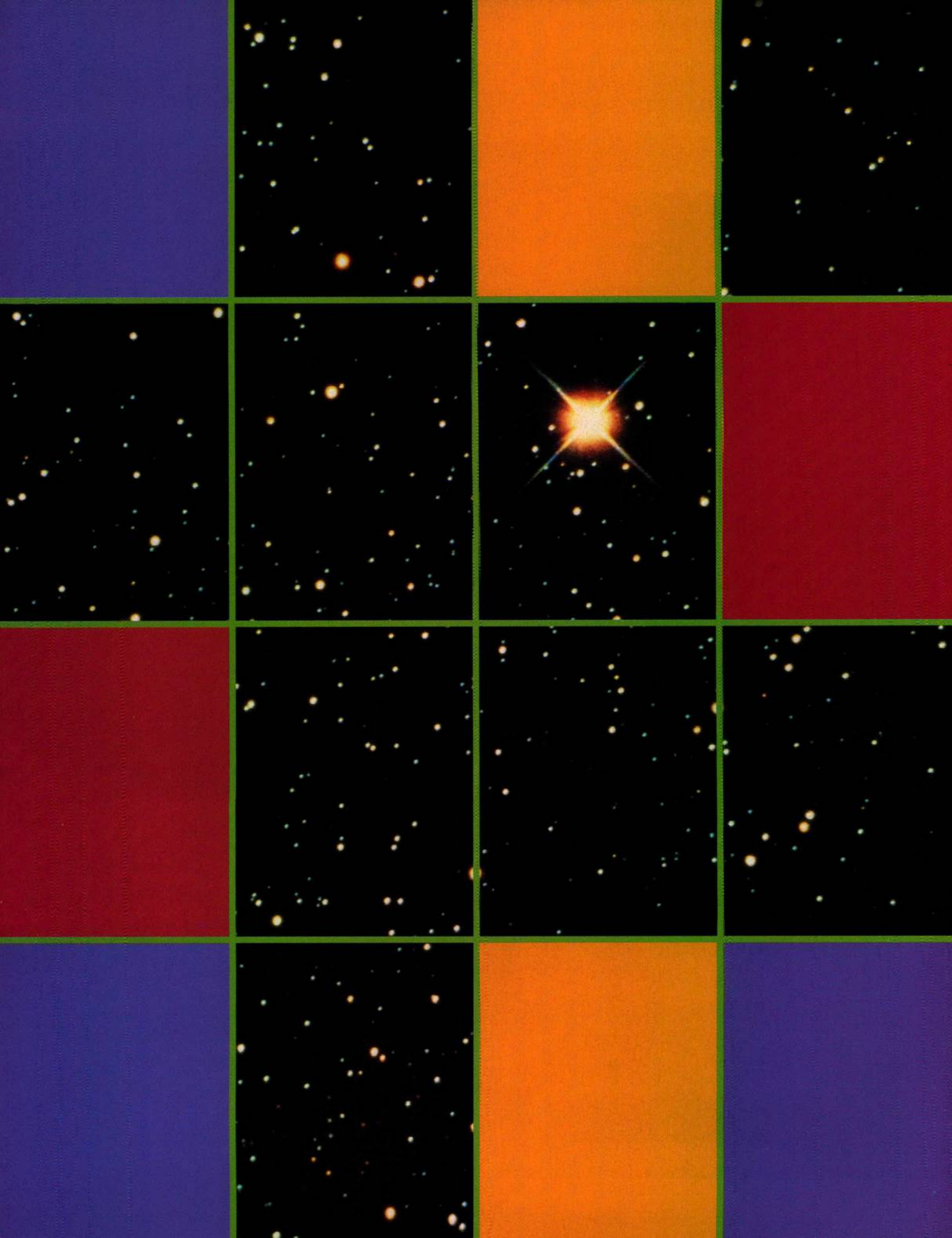
Education also plays an important role at the NSP. Formal lecturers over the years presented a vast range of topics including field etiquette, polar alignment, star-hopping, lunar history and observing, star clubs, and deep-sky observing techniques.

In past years, NSP's half-day canoeing and tubing party on the Niobrara was a free-for-all for about 200 participants who staged water-cannon fights and sneak aqua attacks on river goers. The ice cream social, beach party and barbecue, and catered steak dinner are other big draws. Astrophotography and telescope-making contests enhance the fun. Additional off-site activities embrace the history of the area.

In Valentine, visitors can check out the Cherry County Historical Society Museum and Centennial Hall. Outside of town, look for the Sandhills Museum and the Arthur Bowring Sandhills Ranch.

When clouds ruin other star parties, everyone goes home. Not in Nebraska. There's too much to do. ■

Nancy Hendrickson is a frequent contributor to Astronomy. *She and David Cortner co-authored* Eight Easy Observing Projects for Amateur Astronomers.



SEEKING STAR CLUSTERS

City lights got you down? Find open star clusters even from urban areas.

by Rod Pommier

GLOBULES, KNOTS, AND STRANDS OF GAS in the Milky Way are constantly coalescing into stars that are gravitationally bound in open star clusters. The Pleiades — or Seven Sisters — in Taurus is a familiar example, but each of the hundreds of known open star clusters is unique; they can include a dozen to a couple hundred stars of various brightnesses and colors arranged in a limitless array of densities and distributions. They are visual treats for beginners and advanced observers.

Lee C. Coombs

While amateur astronomers need dark skies to get the best views of galaxies, nebulae, and globular clusters, many open clusters are bright enough to be observed from large light-polluted cities or in moonlit skies. Amateurs can observe open clusters with virtually any type of equipment, including small telescopes and even binoculars.

Regrettably, most amateurs don't hunt for clusters. They stick to the familiar. They return year after year to a few of the 30 open star clusters in the Messier catalog. Yet the *New General Catalogue* (NGC) lists 347 open star clusters, and more than 1,200 open clusters are known; but even that number is a small fraction of many others believed to be obscured by the galactic plane, hidden behind dust, or camouflaged by background stars in the Milky Way. Many of the ones we can see are small, dim, and unimpressive, but some rival the most beautiful open star clusters in the Messier catalog. It's a treat to find, observe, and enjoy them.

I've found many beautiful open clusters buried in the Milky Way this time of year, but I had to dig a little to find them. If any of them were far from the Milky Way in the open sky they would be perennial deep-sky favorites. Eighteenth-century French comet hunter Charles Messier probably didn't include these in his famous list because the region harbors few of his primary targets — comets.

To dig up your own trove of open star clusters, I recommend a scope and a detailed star atlas, such as *Sky Atlas 2000.0* or *Norton's 2000.0*. Hunt for clusters by slewing to their coordinates. (Surprisingly, some popular star atlases don't plot many open clusters.) If your scope doesn't have setting circles, plot the positions of the clusters on your charts, star-hop to their general locations, and then sweep the area for them. In the Northern Hemisphere during May, Ophiuchus marks the Milky Way as it rises from the eastern horizon at sundown, so we will begin our hunt for clusters here. We will move westward along the Galaxy to Vulpecula, Cygnus, Lacerta, and Cassiopeia.

1 THE SUMMER BEEHIVE

The constellation Ophiuchus the Serpent-bearer houses IC 4665, a superb open star cluster. Under dark skies, this broad group of faint stars measuring 41' across is easily visible in a finderscope because it is larger than a full moon. It is so large that it may be difficult to see all at once through your telescope unless you use a very low-power, wide-field eyepiece. Through the telescope you will see a very broad cluster of fairly bright stars, the brightest of which glows at magnitude 6.9. They are widely separated and may continue beyond your view in all directions, so be sure to scan the entire area

1

Jamey Jenkins

until you're convinced you have seen the whole cluster. The large size and even spacing of this cluster's brightest members reminds me of another famous Messier cluster; spring's Beehive Cluster, M44, in Cancer. That's why I refer to IC 4665 as the "Summer Beehive."

2 THE GIANT

Don't remove that low-power, wide-field eyepiece yet. Ophiuchus holds another hidden treasure, the open cluster IC 4756, which is about 1,300 light-years from Earth. While this open cluster is enormous — measuring 52' in diameter, or nearly twice the diameter of a full moon — it exists in obscurity. Under dark skies, it will be visible in a finderscope as a huge, circular, faint glow. Through a telescope, IC 4756 is an exquisite star cluster, extending beyond your telescope's field of view. I couldn't capture it in one frame of the accompanying photograph, taken at the prime focus of my 8-inch f/10 Schmidt-Cassegrain telescope (SCT). The uninitiated must see this cluster, which includes 80 members, to believe its enormous size and extent: the eyepiece will be filled with hundreds of scattered stars, resembling snowflakes in a blizzard. The cluster's brightest star shines at magnitude 8.7.

3 THE ENCHANTRESS

Now slew northwestward to the constellation Vulpecula the Fox. It is home to NGC 6940, a cluster with about 170 stars some 2,100 light-years from Earth. Although NGC 6940 is 31' in diameter, few amateurs know of this enchantress. Made up of uniformly bright stars in a circular to oval pattern

SECRET SUMMER STAR CLUSTERS

Object	Right Ascension	Declination	Size	Magnitude
NGC 225	0h43.4m	+61°47'	12'	7.0
IC 4665	17h46.3m	+05°43'	41'	4.2
IC 4756	18h39.0m	+05°27'	52'	5.4
NGC 6910	20h23.1m	+40°47'	8'	7.4
NGC 6940	20h34.6m	+28°18'	31'	6.3
NGC 7209	22h05.2m	+46°30'	25'	6.7

Rod Pommier

3

Lee C. Coombs

5

Rod Pommier

4

Lee C. Coombs

6

Lee C. Coombs

with a northern crown of yellow and orange suns, the cluster provides a beautiful contrast of colors. It reminds me of the winter cluster M46 in Puppis, which has a foreground planetary nebula NGC 2438 on its southern section. Unfortunately, NGC 6940 doesn't have a planetary, but she does have a bright red foreground star on her southern toe.

4 Y IN THE SKY

Now hop northwesterly to NGC 6910, a secret cluster in Cygnus the Swan. This open cluster in the middle of the summer Milky Way is a few degrees northeast of the bright star Sadr (Gamma [γ] Cygni), which marks the intersection of the perpendicular segments of the Northern Cross. You can pick it up by starting at Sadr, magnitude 7.4, and sweeping your scope on a diagonal to the north and east.

NGC 6910 is a bright, compact open cluster about 5,400 light-years away, with about 50 known members spread across 81'. Its nine brightest stars form an unmistakable, flattened "Y" superimposed on a background of fainter stars. The two stars at the tips of the "Y" glow orange-red, lending beautiful contrasting colors to the cluster, which has a few bright outlying members as well. This cluster vividly reminds me of the wintertime cluster M47 in Puppis, whose brightest members also make a distinctive Y-shaped asterism in a field of fainter stars and bright outlying members.

5 THE PENTAGON

From Cygnus, we continue northwesterly to the constellation Lacerta the Lizard. Here we'll find one of its hidden treasures, the beautiful open cluster NGC 7209, a cluster about 25' in apparent diameter that is easily visible in a finderscope under dark skies. About 2,900 light-years from Earth, NGC 7209 is composed of about 25 stars — the brightest is magnitude 7.0 — framed by five orange and yellow stars arranged in the shape of a pentagon. The brightest of these stars is at the northern corner of the pentagon. Within the boundaries of the pentagon, the numerous fainter members of this cluster are arranged in loops, lines, swirls, and curls, like strings of pearls laid out on black velvet.

6 SAILBOAT CLUSTER

Continue northwestward along the Milky Way to Cassiopeia the Queen, where NGC 225 is docked about 2,100 light-years from Earth. I call NGC 225 the "Sailboat Cluster" because it has a distinctive four-star arc that outlines the leading edge of what could be a sail, inflated by an imaginary wind. This sail is supported by a mast of three to four stars in a line, and they connect to a boat outlined by eight stars arranged in an elongated ellipse. Alas, as Earth turns, the sailboat slowly drifts backward across the sky. I enjoy switching my clock-drive off and watching NGC 225 sail across the eyepiece on a star-filled sea. The brightest star is magnitude 7.0.

These secret star clusters are examples of the thousands of treasures buried within the spring skies above us. Diligent searching will reveal countless others. Happy hunting.

Rod Pommier, a surgeon in the Oregon Health Sciences University School of Medicine's Surgical Oncology Section, is an astrophotographer who lives in the Portland area.

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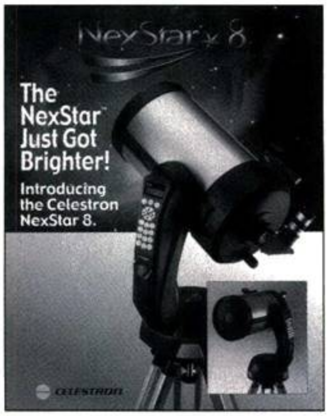
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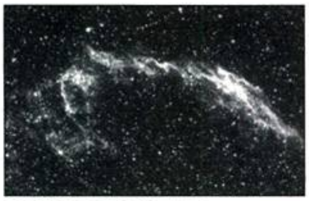

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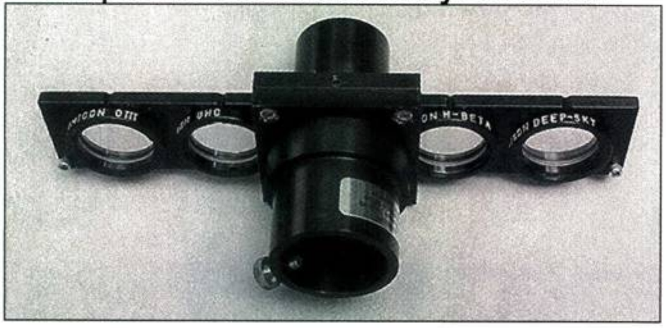

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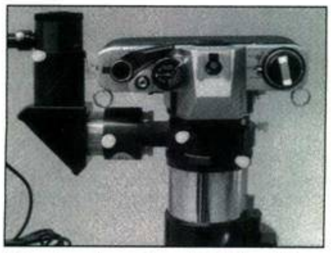

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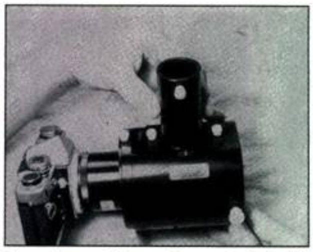

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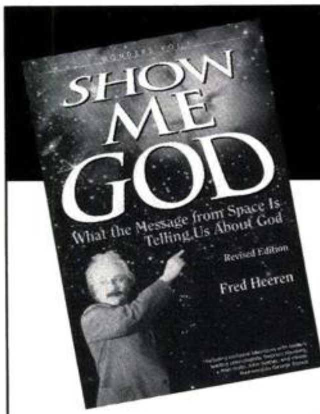

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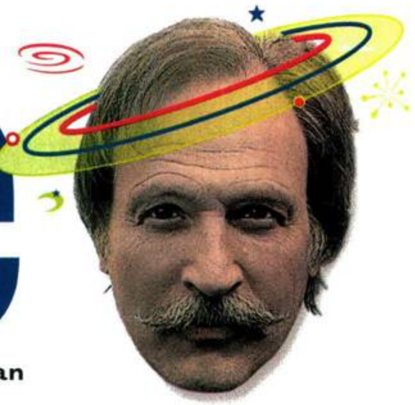

By Bob Berman

Five-Five-Uh-Oh

Surveys show that nearly half of all Americans believe in planetary "influence." With periodic scares about alignments causing earthquakes, and a former U.S. president who consulted an astrologer, you'd think this was 2000 B.C. not A.D. But here we go again: In "new age" circles that have spilled over into the mass media, the nervous buzzword for the past year has been: 5-5-00.

That's the big date when the planets supposedly line up. Even science publications trumpet this "grand conjunction."

People seem to forget all the past alignments that were unaccompanied by disaster, such as 1982's widely publicized "Jupiter Effect," when a similar planet bunching was supposed to send California crashing into the sea.

Amateur and professional astronomers will be contacted by the media (and by nervous astrology-minded acquaintances) during the weeks preceding May's lineup. The press will solicit scientific views. It's important for us to supply factual answers. Shrugging it off simply leaves a vacuum likely to be filled with misinformation.

Here's a crash course on the upcoming alignment, including ten arguments that undermine astrology's hocus-pocus.

First the specifics. From May 6 to May 21, all the planets from Mercury through Saturn will huddle in a 25° circle surrounding the sun. Publicity aside, there's nothing special about May 5; the maximum crowding occurs on May 3 and 4 when the moon joins the party, or May 16 if you exclude the moon. For backyard observers the whole thing has all the excitement of an overcast day; solar glare hides it completely.

Despite the present commotion, a five-planet bunching is not unusual and occurs every few years. In gravitational terms, the biweekly lineup of sun and moon routinely produces spring tides that raise oceans an average of three feet worldwide. The presence of these five planets in nearly the same vector now raises tides an extra 0.005 inch. This is microscopic, too small to matter.

Since sun and moon produce a barely detectable statistical effect on earthquake genesis, the presence of the planets' gravities, which are thousands of times weaker, cannot make the ground shake. It is thus no surprise that computer searches of historical alignments show no correlation with Earth's physical (or for that matter, political) fortunes.

If the topic shifts from this particular planet-scare to astrology in general, a can of worms is opened because astrology can only be effectively investigated statistically. Individual anecdotes are of little use in gauging its validity because of the built-in Catch-22 created by astrology's maxim that "stars do not compel, they only impel." If a career soldier's horoscope has Mars in Aries, an astrologer will likely interpret that as support for the configuration's supposed link with a military career. But a florist with Mars in Aries will be assumed to have used his own free will in choosing an occupation. Astrology is therefore never wrong. Only by surveying the horoscopes of a large number of people (as one study did when looking at 5,000 marines) can it be found that Mars appears randomly in Aries in such a group.

Unfortunately, astronomers' replies to astrological questions are usually inadequate. The classic debunking argument is to point out that astrology doesn't follow zodiacal constellations. If you were born February 3 under the sign of Aquarius, the sun was really in Capricornus on that date. That astrology's signs don't correspond with constellations may be slightly unsettling to novices, but it means nothing to serious astrologers. They have a ready response: "We're aware of precession. We care solely about the influence of that piece of sky; it doesn't matter which star pattern sits there now. And anyway, aren't astronomy's own constellation boundaries arbitrary, drawn only in 1926?"

What do you say then?

When somebody asks your sign, it's tempting to brush it off, saying, "Slippery When Wet." Many treat astrology as a kind of religion and do not take kindly to facts contradicting their beliefs. But if a listener is open-minded, or if you are speaking with a reporter, it is easy to make a compelling case in a few short minutes.

One might start at the beginning, at origins. The Babylonians who created astrology (and Ptolemy, who later codified it) believed that planets were gods circling Earth, with each planet's "influence" derived from its appearance or motion. For example, Mars's reddish color must stem from fire and blood and hence be connected with war and aggression. But knowing today that there is no blood on Mars ought to end such a line of reasoning. Also, we now know that Mars varies its distance from us enormously. This eightfold shift makes Mars greatly alter its brightness and gravitational effect (by a factor of 64), yet astrology still assumes Mars's "influence" to be uniform and independent of its changing distance.

But if an object's distance does not matter, then why not include the influence on a person's birth of the Andromeda Galaxy with its trillion suns and planets?

And speaking of birth, why is the moment of birth the critical moment that fixes the horoscope? Why not conception? And if a Caesarian birth is put off by two hours (which changes every "house" and "rising sign") is the child's personality and destiny forever altered?

Then there's the problem of fraternal twins. Born nearly simultaneously, they are astrologically identical, yet studies show no greater correspondence of future illnesses or eventual date of death than other siblings. If astrology is valid, why do people with identical horoscopes have dissimilar personalities and destinies?

Sun-sign astrology, the simplest and most popular form, has been the most thoroughly investigated. Dozens of attributes from hair color to occupation have been found to be independent of date of birth. Millions of personality questionnaires and psychological evaluations show no hint of a "Taurus" or "Leo" personality in particular months. There is nothing to the idea that humans come in 12 character varieties that are birth-date related.

Two large studies (11,000 subjects) examining marriages and divorces have shown absolute randomization among sun-sign pairs. If there are "compatible" or "incompatible" combinations, it has somehow escaped the process of matrimony. Compatible matches (such as Libra and Gemini) get divorced as often as incompatible matches.

Studies also show why astrology seems to work. In the 1980s, seven separate studies asked professional astrologers to prepare readings of subjects. These subjects then had to decide which of several horoscope readings fit them best. When trying to select their reading from among a stack of two to five, the results were completely random. People were just as satisfied with incorrect horoscopes as correct ones. The lesson is clear: People "see themselves" in a horoscope interpretation, but only if they believe it is theirs.

We are safe from cosmic meddling. The planets sway neither earthquake genesis nor personal romance.

But wait. I fell in love with the planets as a child and the romance is still strong. And my devotion to instrumentation has definitely eaten into my wallet. Jupiter has made me poorer.

Stop the presses: Planets do *influence* our lives. ◼

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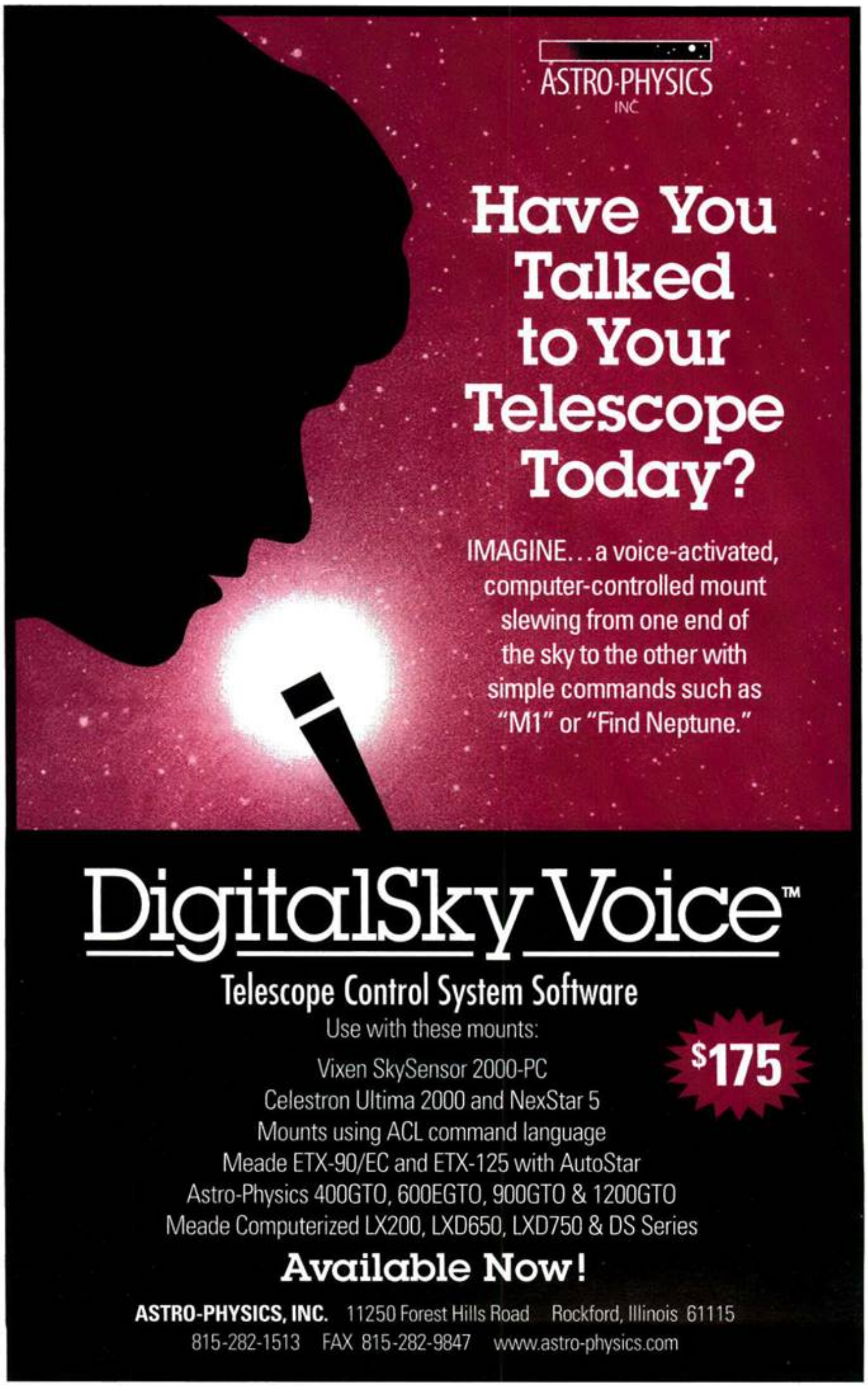

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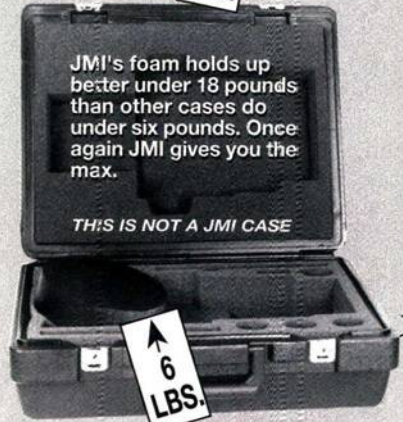

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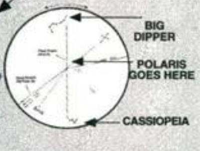

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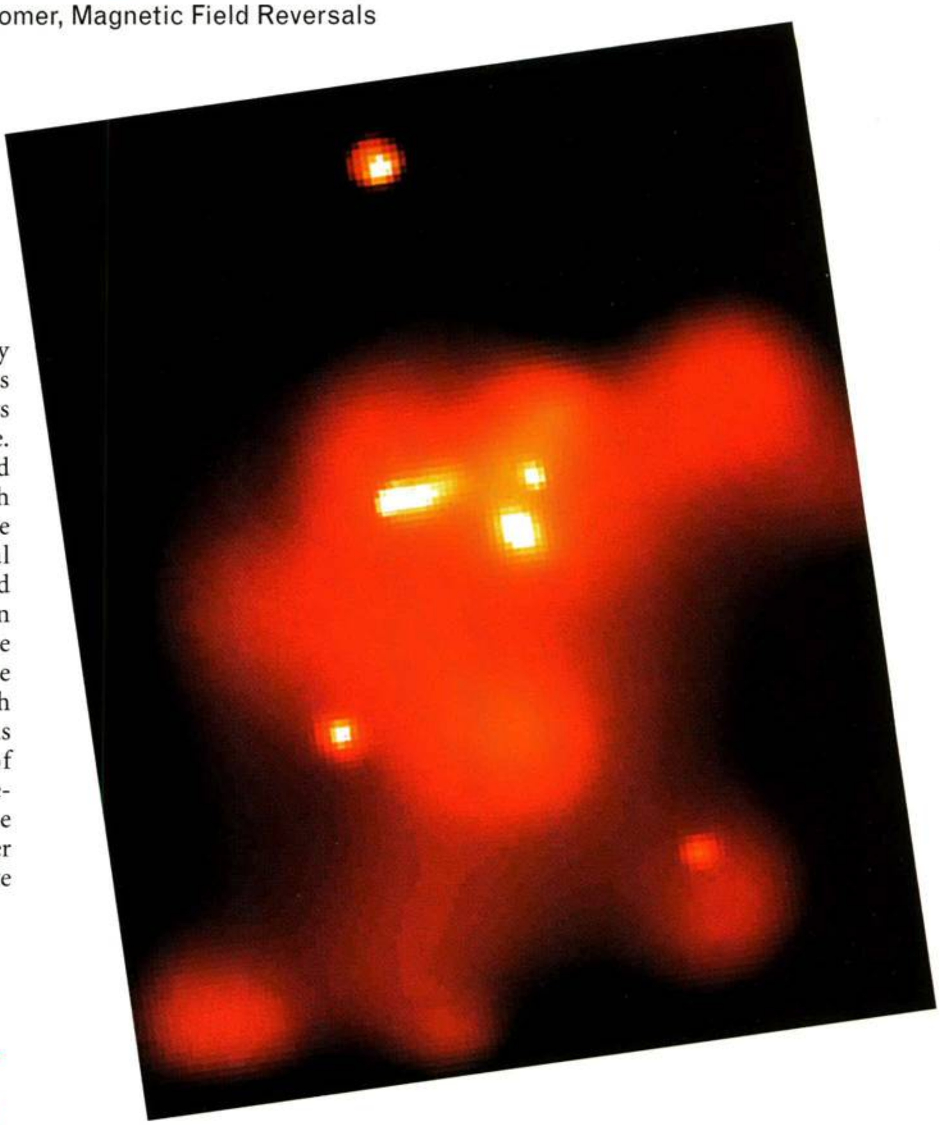
ask Astro

Black Holes, Becoming an Astronomer, Magnetic Field Reversals

Q: How do astronomers detect x-ray emission from a black hole, when nothing, not even light, can escape? — *Shayne Davies, St. Clair, Australia*

A: When astronomers detect x-ray emission from a black hole such as Cygnus X-1, they aren't seeing x rays emanating from within the black hole. Instead, the x rays come from gas and dust inside the accretion disk, which feeds matter to the black hole. The black hole's powerful gravitational field whips the gas and dust around the disk at speeds that can reach an appreciable fraction (sometimes more than half) of the speed of light. The particles and atoms collide with stupendous violence. These collisions heat the material to millions of degrees, causing the superheated material to emit x rays. So the x rays can be likened to the death screams of matter as it's about to plunge into the ultimate abyss. — *Robert Naeye, senior editor*



This new Chandra image shows x-ray emission coming from the vicinity of the monster black hole in the Galaxy's center. The x-rays aren't emitted by the black hole itself.

NASA/MIT/Penn State University

Q: I am a junior in high school and would love to pursue a career in astronomy. I own a telescope, a field guide, a copy of your magazine, and I am ready to go. Where do I start? — *Aliisa Aarnio, Ashburn, Virginia*

A: A variety of options exist for pursuing a career in astronomy. If you want to become an astronomy researcher, take as much math and physics in high school and college as you can. If you enjoy these courses and do well in them and maintain your passion for astronomy, you can then do graduate work at one of the many universities that offer Ph.D.s in astronomy and astrophysics. Ph.D. astronomers work for universities, observatories, NASA, and other research centers, although competition for the best jobs can often be fierce these days.

If you have access to the World Wide Web, you can find much more information on this path at the American Astronomical Society website: www.aas.org/education/career.html. The AAS even offers a brochure about careers in astronomy.

Even if you don't pursue astronomy all the way to a Ph.D. (which takes 4 years of college and at least 4 years of graduate school), you can still become part of the astronomical community in other ways. Many astronomy enthusiasts become science teachers in middle and high school, work for a planetarium or science museum, or do public outreach in astronomy, just like the staff of *Astronomy*.

For more on projects and paths in astronomy education, you can look at the Astronomical Society of the Pacific's website at www.aspsky.org/education.html. — *Andrew Fraknoi, Foothill College and the Astronomical Society of the Pacific*

Just as space shuttle astronauts don't feel their 18,000-mile-per-hour orbital velocity around Earth, people on the ground don't feel Earth's orbital velocity around the sun. NASA

Q: Earth's magnetic field has flip-flopped in the past. If this were to happen today, would it happen gradually or suddenly, and what would be the effect on life? — *Charles Harrison, Rogersville, Missouri*

A: Earth's magnetic field has changed polarity many times throughout our planet's history. The record of these geomagnetic reversals is preserved in layers of sediment, in rocks formed from lava, and in the magnetization of the seafloor crust.

Geomagnetic reversals occur at random intervals, ranging from a few tens of thousands of years to more than a million years. On average, the field reverses about once every 200,000 years. From a geological perspective, a reversal event occurs very quickly, taking about 5,000 years. During a reversal, the magnetic field does not completely disappear. Instead, the field diminishes to about 20 percent of its usual strength and temporarily takes on a relatively disordered structure.

Earth's magnetic field provides some shielding from cosmic rays, so during a reversal the cosmic radiation striking Earth increases. Because the atmosphere provides our main shield against cosmic rays, the increase in cosmic radiation is not a cause for alarm. There is likely to be some effect on climate during a field reversal. But we do not yet understand the mechanisms well enough to predict the nature or magnitude of the effects.

Although there are likely to be some minor effects on life, including possible small increases in mutation rates induced by the moderate increase in cosmic rays, there is no evidence that magnetic reversals have a significant negative effect on life. Organisms that rely on magnetic orientation during migration might be disrupted. But reversal events are so slow that some adaptation is likely to occur.

The last major reversal occurred about 700,000 years ago, when human ancestors already were relatively advanced. During the 3 million years that have elapsed since the time that putative humanoid ancestors dwelled in Africa, Earth's magnetic field has reversed about a dozen times with no significant disturbance to life.

Earth's magnetic field changes slowly during a reversal event. Even in normal times, the intensity of Earth's magnetic field commonly varies by as much as 50 percent over a few thousand years. In fact, while the magnetic field intensity has decreased a few percent over the past 100 years, there is no reason to believe that (and no way to tell if) Earth's magnetic field is entering a reversal phase. This decrease is probably just a reflection of normal "geomagnetic weather," and the intensity will likely increase in the future. But the past is a reliable guide to the future. It is virtually certain that Earth's magnetic field will reverse many times more in the future, with no cause for alarm. — *Eugene H. Levy, University of Arizona*

Q: Why don't we feel the effects of Earth's motion? — *Baiju Mathew, Surat, India*

A: Isaac Newton said it best: An object in motion tends to stay in motion unless acted upon by an outside force. If there's no change in motion, there's no force. So if you move in a straight line, you won't feel any force.

Imagine you are in a car traveling 60 miles an hour. As long as you are on a straight road, you don't feel the motion. You can see it as trees and hills go by, but there is no force acting on you, so you don't feel the motion.

Now try turning the car. You feel the curve as a force in the opposite direction (if you turn left, you feel as if you are being pushed to the right). What's really happening is that you want to go straight, but the car is turning. To turn you too, the car has to apply a force on you. If you make a sharp turn, the force is large, and you really feel it. A slow, gradual turn applies very little force, and you might not even notice it.

The same holds true for Earth. We are in constant motion: Earth rotates on its axis; it revolves around the sun; the sun revolves around the center of the Galaxy. But the distances are so huge that all these curves are slow and gradual, so we don't feel them very strongly. For example, the force that you experience from the rotating Earth is only 0.003 times the force of gravity downward. No wonder you can't feel it! — *Phil Plait, Advanced Computer Concepts, Inc. Check out Phil's website (www.badastronomy.com).* ◼

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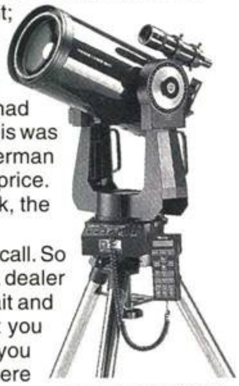

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BOOKS

The Chronological Encyclopedia of Discoveries in Space

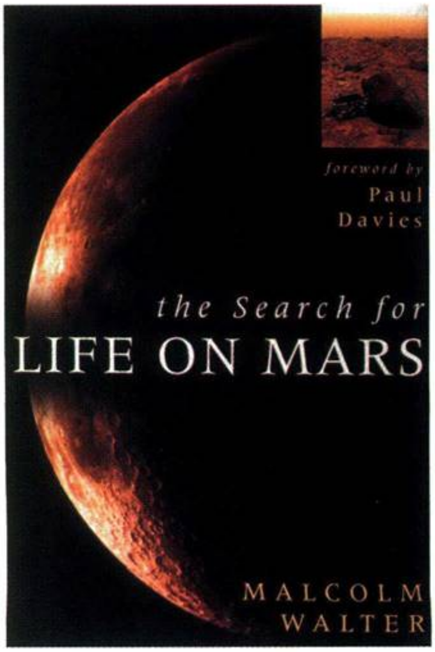
Robert Zimmerman, 440 pages, Oryx Press, Phoenix, Arizona, 1999; ISBN 1-57356-196-7; hardcover, $85.

▶ If you want to know about every spacecraft ever launched and what each mission accomplished, this handy reference volume from a frequent *Astronomy* contributor and the author of *Genesis: The Story of Apollo 8*, Robert Zimmerman, is just for you. All entries are cross-referenced alphabetically and chronologically for easy use. The encyclopedia covers every mission (more than 1,000 total), from the 1957 Sputnik satellite through those launched in December 1999. The entries include all nationalities and range from manned missions to scientific probes, communication and weather satellites, military missions, and commercial ventures. For more information, visit www.oryxpress.com.

The Search for Life on Mars

Malcolm Walter, 170 pages, Perseus Books, Cambridge, Mass., 1999; ISBN 0-7382-0124-3; hardcover, $25.

▶ For NASA and Soviet aerospace engineers, Mars has been a source of great frustration. But in this short book by Malcolm Walter, an Australian expert on extremophiles (microbes living in hot springs), it is also a potential source of great knowledge about the nature and possibilities of life. The book starts with a historical overview and moves quickly to a discussion of the origin and nature of life on Earth. Walter next explains why evidence for life in Mars meteorite ALH84001 will always be inconclusive at best. The final chapters cover future Mars exploration plans and what scientists can learn by discovering martian life. Walter emphasizes the similarities between early Earth and Mars, and he convincingly demonstrates that our best chance of finding martian life is to look under the surface of the Red Planet.



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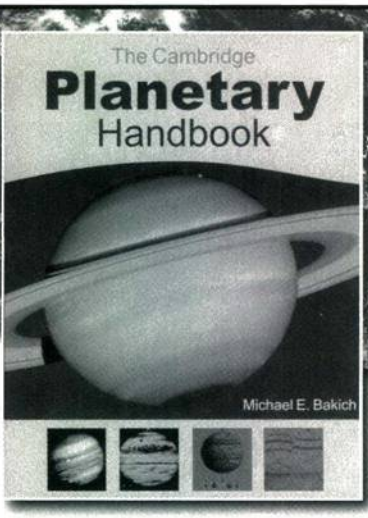

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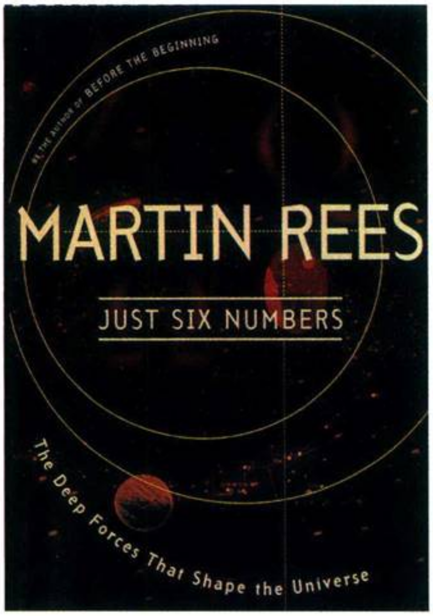

BY THE AUTHOR OF BEFORE THE BEGINNING
MARTIN REES
JUST SIX NUMBERS
The Deep Forces That Shape the Universe

Just Six Numbers: The Deep Forces That Shape the Universe

Martin Rees, 173 pages, Basic Books, New York, 2000; ISBN 0-465-03672-4; hardcover, $22.

▶ Why is our universe the way it is? And why do the physical laws that govern our universe allow life to be possible? These are the central questions that Cambridge University astrophysicist Martin Rees, Britain's Astronomer Royal, explores in this provocative follow-up to his superb 1997 book *Before the Beginning*.

In chapter 1, Rees introduces the "six numbers" in the title: the strength of gravity relative to electrical forces (N), how firmly atomic nuclei are bound together (ε), the ratio of matter density to the density needed to close the universe (Ω), the strength of a cosmological constant (λ), the ratio of two fundamental energies (Q), and the number of spatial dimensions (D). In Rees's words, these numbers constitute a "recipe for a universe."

Remarkably, each of these six numbers appears to be "fine-tuned" to make life possible. For example, if gravity was slightly stronger, then the universe would have collapsed back upon itself shortly after the Big Bang. But if gravity was slightly weaker, then galaxies, stars, and planets never could have formed. "Is this providence? Is it coincidence? Are these numbers the outcome of a 'theory of everything' that uniquely fixes them? None of these interpretations seems compelling," writes Rees.

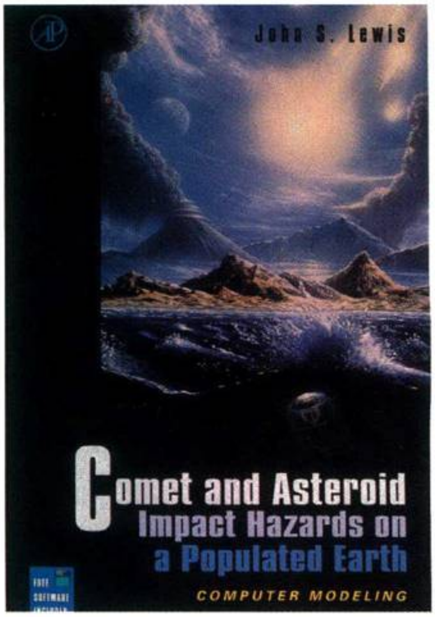
As Rees explains each of these six numbers in subsequent chapters, he provides an overview of the current state of big bang cosmology. The chapters paint broad brushstrokes over topics such as dark matter, inflation, the possibility of an accelerating universe, and superstrings. Rees's approach leads to a fast-paced and accessible narrative while sacrificing detail and the names of scientists who are doing cutting-edge research.

Just Six Numbers is essentially about the anthropic principle, which states that the existence of life means the universe must have been set up in such a way to make life possible. Curiously, Rees never mentions "anthropic" in his book, as if it's some kind of dirty word. Some physicists tend to dismiss the anthropic principle as tautological hogwash, while others take the concept more seriously. (Rees told me, "I purposely avoided the word 'anthropic' because for some people it has a negative and flaky association.")

In the final chapters, Rees offers a possible solution to the fine-tuning mystery. Perhaps our universe is just one of countless universes existing in a so-called "multiverse." We live in one of the few universes conducive to life because if we didn't, we wouldn't be around to ask these questions. Rees even speculates on how other universes might differ from ours.

For those who think this multiverse idea is crazy or unscientific, Rees points out that it makes certain predictions about our universe that can be tested by future experiments and observations. "I think the multiverse genuinely lies within the province of science," he argues, "even though it is plainly still no more than a tentative hypothesis."

While I would have preferred more detail on certain subjects, this is an utterly fascinating and highly readable overview of cosmology and the anthropic principle. Rees's "spare the details" approach enabled me to finish this short book in three sittings. But readers hungering for greater depth would be best served elsewhere. — *Robert Naeye*



Comet and Asteroid Impact Hazards on a Populated Earth: Computer Modeling

John S. Lewis, 200 pages, Academic Press, New York, 2000; ISBN 0-12-446760-1; paperback, $49.95.

▶ For the first time, the public can read about computer simulations of the hazards of comet and asteroid impacts on Earth. Lewis, of the University of Arizona, describes the future of impacts on Earth, taking into account our exploding population and early warning possibilities. A table labeled "Damage, Injuries, Deaths, and Very Close Calls" recounts historical meteorite or comet falls and makes for fascinating reading. The book is rather technical for a general audience, presenting many graphs, statistical analyses, and even a computer disk of the modeling.

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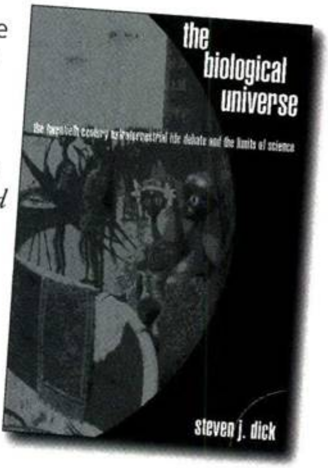
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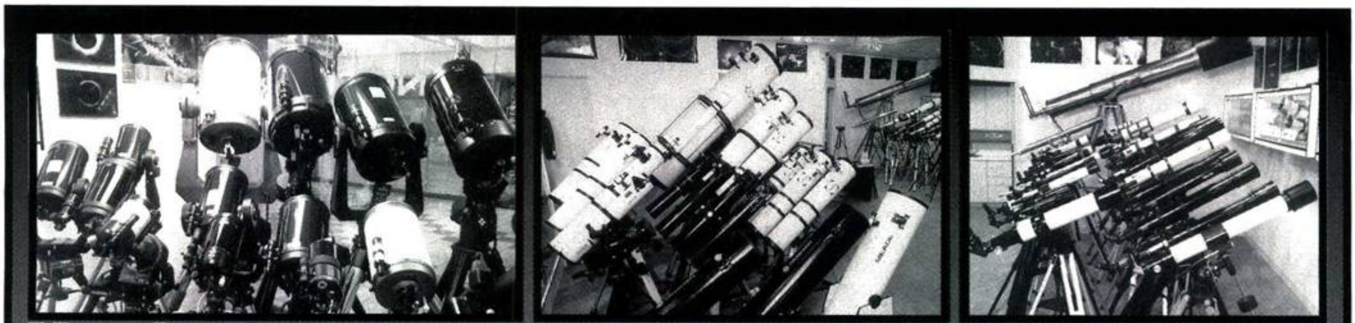

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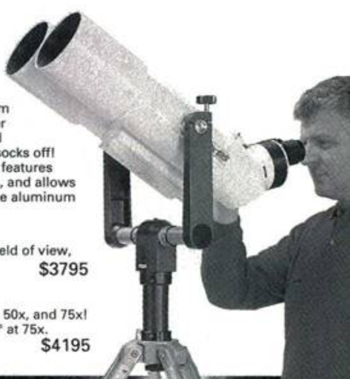

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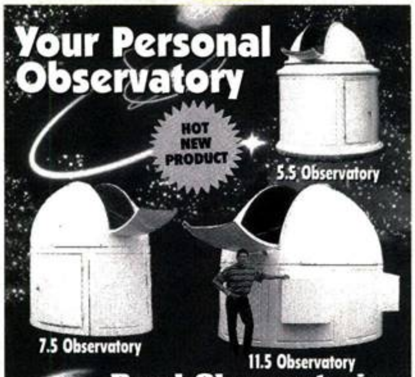

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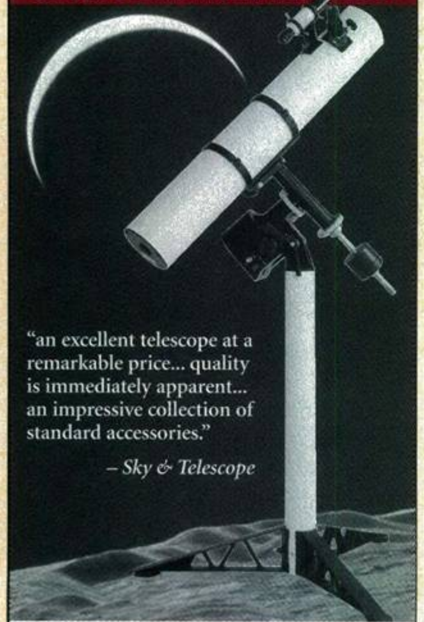

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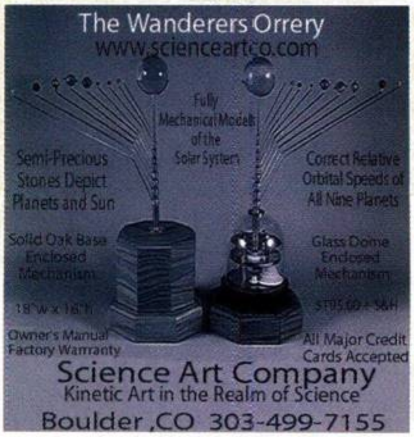

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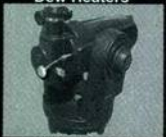

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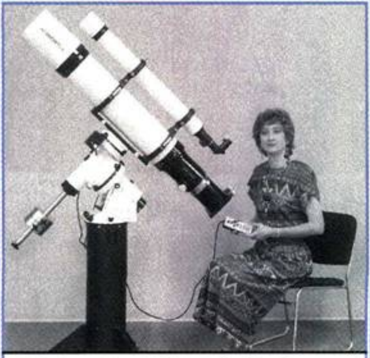

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A LOOKING AHEAD

MAY

Star parties offer participants more than the opportunity to gaze in wonder at their favorite celestial object. Instead, they center around educating beginners and enhancing the skills and knowledge of seasoned astronomers. The condensed list below includes some star parties that will improve your viewing skills and increase your enjoyment of the skies:

In California, the annual **International Amateur-Professional Photoelectric Photometry (IAPPP)** meeting precedes **The Riverside Telescope Makers Conference** and includes a workshop on **May 24** covering photometry techniques using a CCD camera. For information, call (909) 948-2205; e-mail, stephens@foxandstephens.com

Summer and fall astronomy camps geared toward teens, adults, and educators are sponsored by the **University of Arizona Alumni Association.** Contact Don McCarthy, 933 N. Cherry Ave., Tucson, AZ 85721-0065; (520) 621-4079; e-mail, dmccarthy@as.arizona.edu; website, http://ethel.as.arizona.edu/astro_camp.

Travel to Austria in July for the **International Conference on Catastrophic Events and Mass Extinctions: Impacts and Beyond.** For information, please access the conference website at http://cass.jsc.nasa.gov/meetings/impact2000 or contact Elizabeth Wagganer, Impact 2000 Conference, Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston, TX 77058-1113; (281) 486-2177; e-mail, wagganer@lpi.jsc.nasa.gov.

Also in July, the Astronomical Society of the Pacific offers **"The Universe in the Classroom 2000."** For information and registration, contact the ASP, Workshop information, 390 Ashton Ave., San Francisco, CA 94112; (415) 337-1100 x100; e-mail, meeting@aspsky.org; website, www.aspsky.org/.

At the end of August, the Institute of Physics, Lodz University in Poland hosts the **European Symposium on Occultation Projects.** For information, contact Marek Zawilski, e-mail, mrkzaw@ck-sg.p.lodz.pl or Joan and David Dunham, 7006 Megan Lane, Greenbelt, MD 20770; (301) 474-4722; e-mail, dunham@erols.com.

John Shibley

Star parties include solar observing sessions.

And for those who really like to plan ahead, there's the **2001 Queensland Astronomy Education Conference** in Queensland, Australia, on **March 31, 2001.** Contact Paul Floyd, e-mail, ssemps@ozemail.com.au; website, http://www.ozemail.com.au/~ssemps/confer/index.html.

MAY 3

The Silicon Valley Astronomy Lecture Series — "Cold Hard Worlds at the Edge of the Solar System."

▶ Smithwick Theater, Foothill College, Los Altos, California. Sponsored by NASA's Ames Research Center, Foothill College, the Astronomical Society of the Pacific, and the SETI Institute. Call (650) 949-7888 for more information.

MAY 4

Space Day/Cyber Space Day — "Living and Working in Space."

▶ National Air and Space Museum, Washington, D.C. Cyber Space Day is a live, interactive webcast hosted by respected journalists. Website, http://www.spaceday.com.

MAY 5 – 6

North Central Region of the Astronomical League 2000

▶ La Crosse, Wisconsin. Contact Robert Allen, (608) 785-8669; allen.robe@uwlax.edu. Website, http://perth.uwlax.edu/planetarium/NCRAL2000.html.

MAY 6

STARCONN 2000

▶ Contact the Astronomical Society of Greater Hartford, P.O. Box 2271, Hartford, CT 06145-2271; (860) 521-0474; e-mail, vega154@aol.com; website, www.cshore.com/royce/asgh.

MAY 6

Astronomical Society of Nevada Star Party

▶ University of Nevada – Reno. Call Bob Graf, (775) 329-8809; e-mail, syzygy5@hotmail.com; website, http://members.theglobe.com/astronomynv.

MAY 8 – 12

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MAY 26 – 29

Juan de Fuca Festival and Hurricane Ridge Star Party

▶ Port Angeles, Washington. Contact John Gallagher, (360) 417-5191; e-mail, jgalla@orca.esd114.wednet.edu.

MAY 27

Shreveport-Bossier Astronomical Society Star Party

▶ Ralph A. Worley Observatory. Shreveport, Louisiana. Contact Cran Lucas, (318) 797-1524; e-mail, clucas@softdisk.com;website,http://www.lsus.edu/nonprofit/sbas/. ▣

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or to cryback@astronomy.com. Look for additional events at http://www.astronomy.com.

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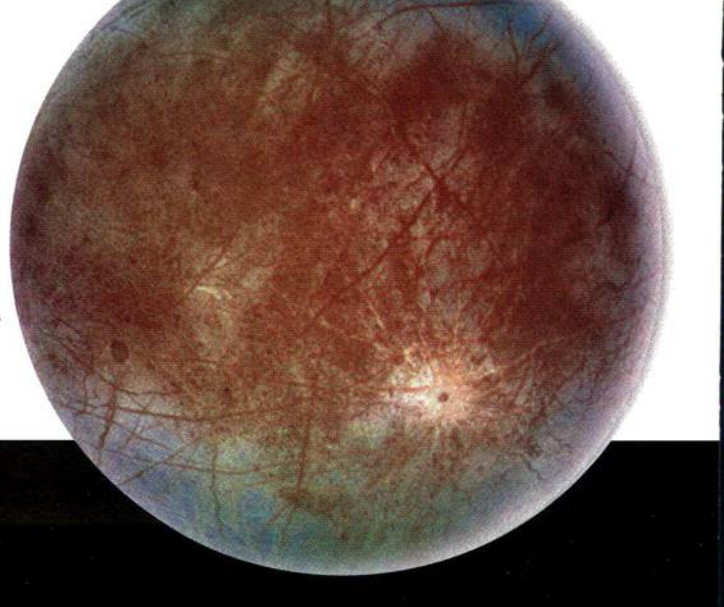

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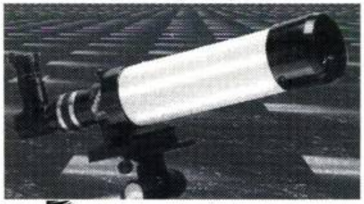

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SHUTTLE LAUNCH

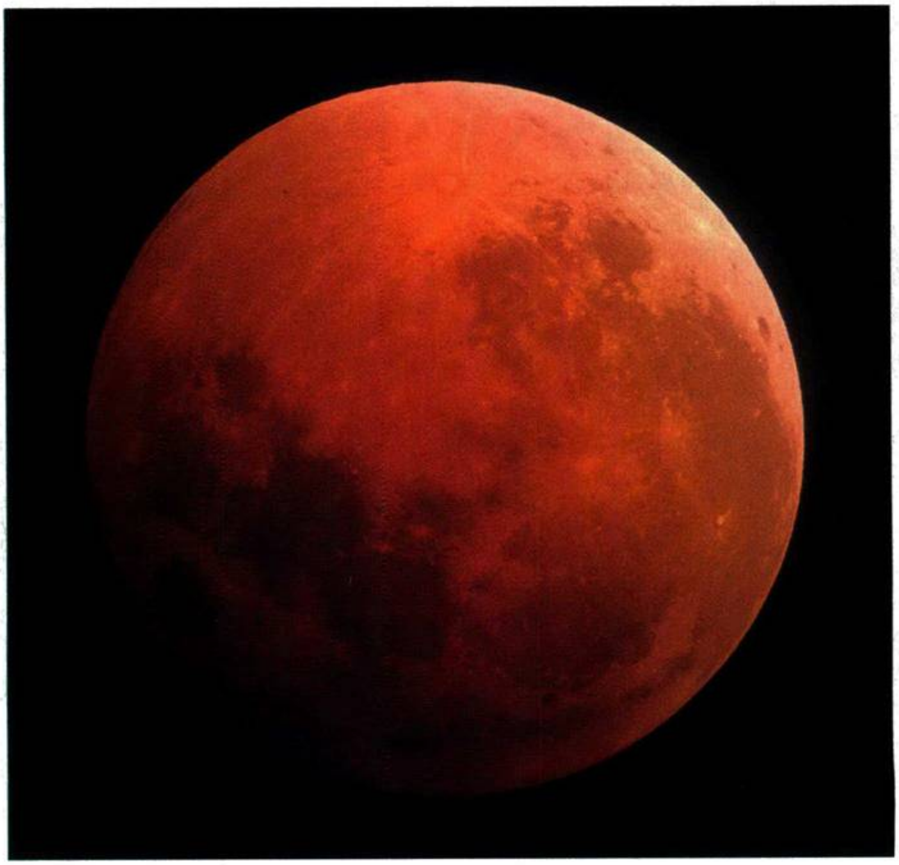
Filming Liftoff

▶ At 6 P.M. on a clear and cool Sunday night, December 19, 1999, we make our way across the NASA causeway to view the launch of space shuttle flight STS-103. Discovery's mission is to get the Hubble Space Telescope back up and running again.

We are greeted by NASA personnel and guided to our parking spot on the grass strip with military precision. NASA really does things right. The viewing area contains portable concession and gift stands and restrooms. The site also has a clear and audible public address system, which they use to broadcast launch status updates, general information, as well as the pre-flight communications between the shuttle crew and mission control.

As we sit near the water's edge, looking across the Banana River at the launch pad, we hear an announcement that catches our attention. The official-sounding voice calmly states "In the unlikely event of an accident in the first minute and a half of the launch, please seek shelter in the nearest air-conditioned building as quickly as possible." My wife and I exchange a nervous look. "Hmm, okay. . . . Good tip. . . . Now exactly where is that nearest air-conditioned building?" We look around for the closest safe haven.

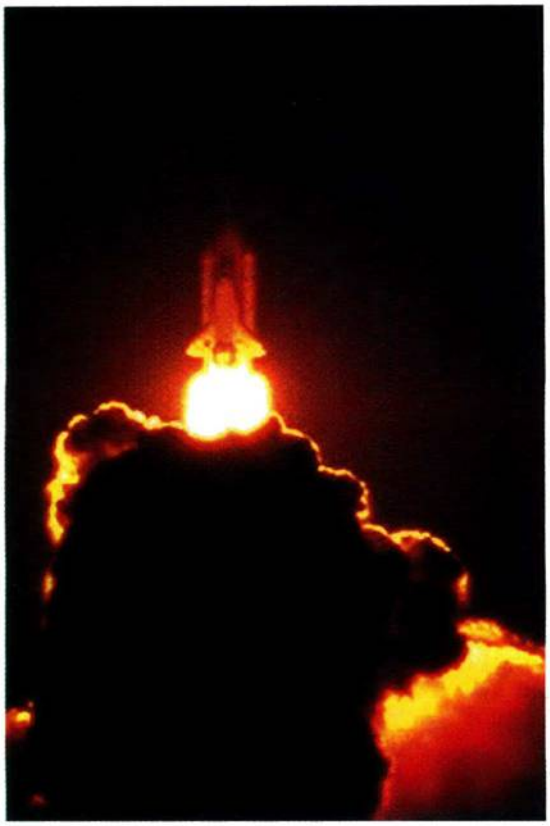
Soon our safety concerns fade into the background as we enjoy the beautiful local wildlife. The Kennedy Space Center is part of a national wildlife refuge that bald eagles, sea turtles, manatees,



Totality

PEDRO RÉ

(14-inch f/16 SCT, 10-second exposure taken January 21, 2000)



Discovery Zooms toward Hubble

DOUG MURRAY

(300mm lens at f/4.5, Fuji Provia ISO 100 slide film, 1/500-second exposure taken December 19, 1999)

Darkness during a Lunar Eclipse

JEFFREY PETTITT

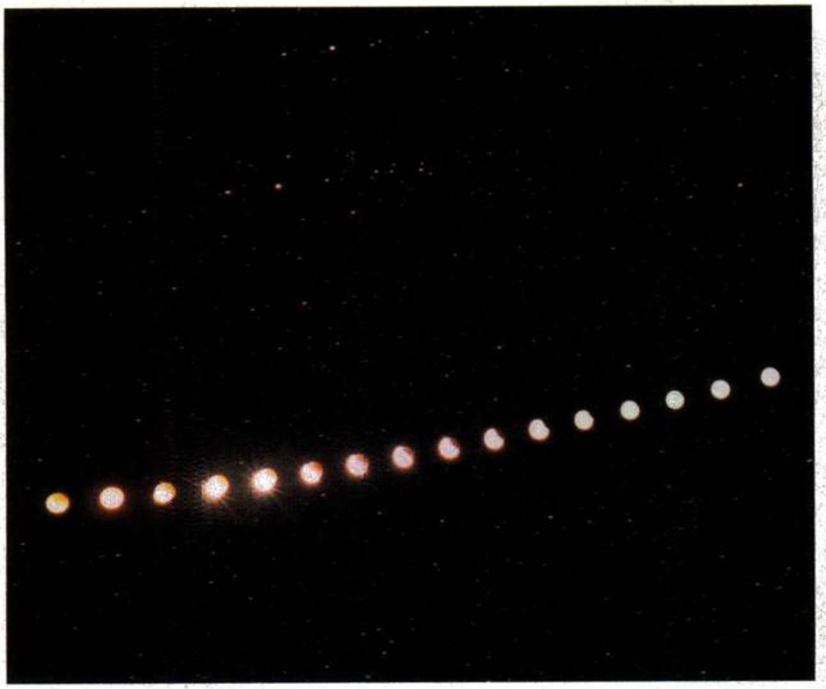
(24mm lens, two 30-minute exposures with 3-minute gaps at totality, taken January 20, 2000)

and alligators call home. According to NASA, the biggest problem they have with alligators is that they enjoy sunbathing on the landing runway.

It is a perfect night for a launch: clear skies and 65° F. We spend time awaiting the 7:50 P.M. launch by seeing how many celestial objects my wife, Tracie, and my daughters, Tara and Kayla, can find in the 4th-magnitude skies. They find the moon, Jupiter, Saturn, Orion, Cassiopeia, and the Pleiades. Not bad . . . but I am still working on them.

This is my first launch, so I am eager to photograph the event, although I don't have a clue as to what would be the best film, shutter, and exposure combination for a night launch. I came across the Florida Today website, which has award-winning coverage of space events, including advice on photographing a daytime shuttle launch. A quick e-mail to the editor, Mark DeCotis, results in the following advice: "Per our Pulitzer Prize nominated photographer, Mr. Michael R. Brown, who has photographed all but two shuttle launches, use ISO 100 film, 1/500 of a second shutter speed at f/4, for a night launch." Since these are exactly the same settings I use to photograph baseball games on a sunny day, my first thought was that these guys have been sniffing way too much rocket fuel. But who I am to second-guess them? So ISO 100, 1/500 of a second at f/4 it is.

Finally over the public address system we hear those familiar words . . . "10, 9, 8," I quickly double-check the camera settings, "7, 6, 5," the shuttle is centered in my camera's viewfinder,



Exit of a Lunar Eclipse

GREGORY GAGE

(50mm lens at f/8, Fuji ISO 400 film, 1/500-second to 15-second exposures every 6 minutes taken January 20 and 21, 1999)

Colors of the Eclipse

DOMINIC CANTIN

(10-inch f/4 SCT, Fuji Superia 800 film, 2-second exposure taken January 20, 2000)

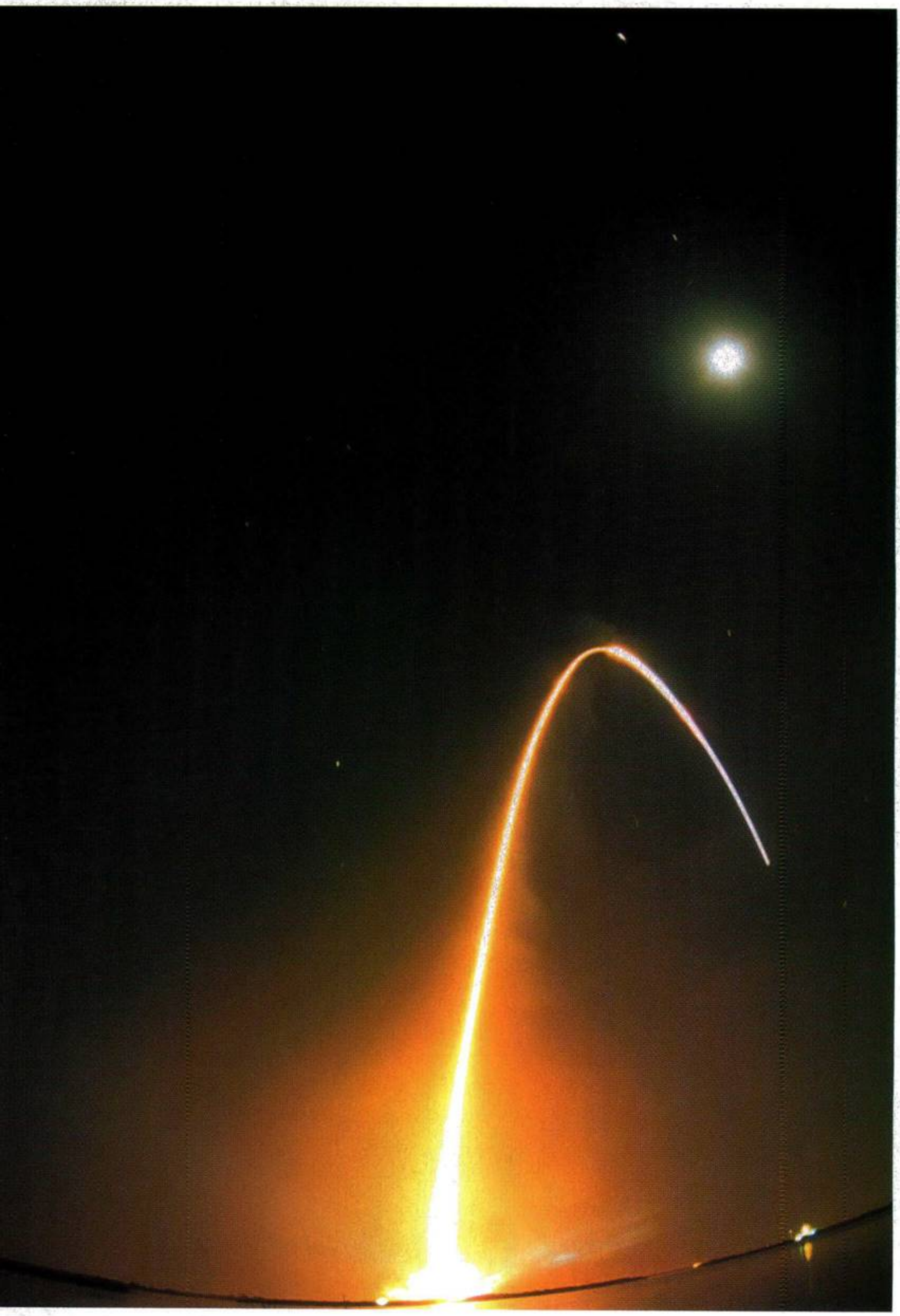
"4, 3, 2, 1, IGNITION!" Instantly I see a small, bright-red flash of light at the bottom of the shuttle, then nothing — just black. I look away from the viewfinder to see what is going on. The rocket engines produced a huge cloud of white smoke and steam that completely hid the shuttle, tower, and all lights.

Then, the tip of the shuttle appears above the smoke. I raise the camera and start taking pictures. The entire shuttle moves above the expanding cloud of smoke and is outlined in a brilliant orange-red light from the shuttle's engines. Ten seconds after ignition, the shuttle clears the pad and gently arcs and turns east. Night has turned into day, as the entire sky, land, and water is now bathed in a bright orange light from rocket flames.

The shuttle rolls completely upside down and continues climbing gracefully into the night sky. My fingers are still dancing across the shutter and the film advance lever of my trusty 37-year-old camera. The rocket's roar is just now reaching us.

We look straight up into the business end of the shuttle's three main engines, which looks like a single, bright-white disk. The shuttle appears near Jupiter, and as the white engine glow gets smaller it looks as if Jupiter has a twin. The shuttle is now about the size of a star, going . . . going . . . gone. We sit there, staring up at the stars in absolute amazement of the spectacle that just unfolded before us. ■

Doug Murray works as a Systems Analyst for Florida Power and Light Company.

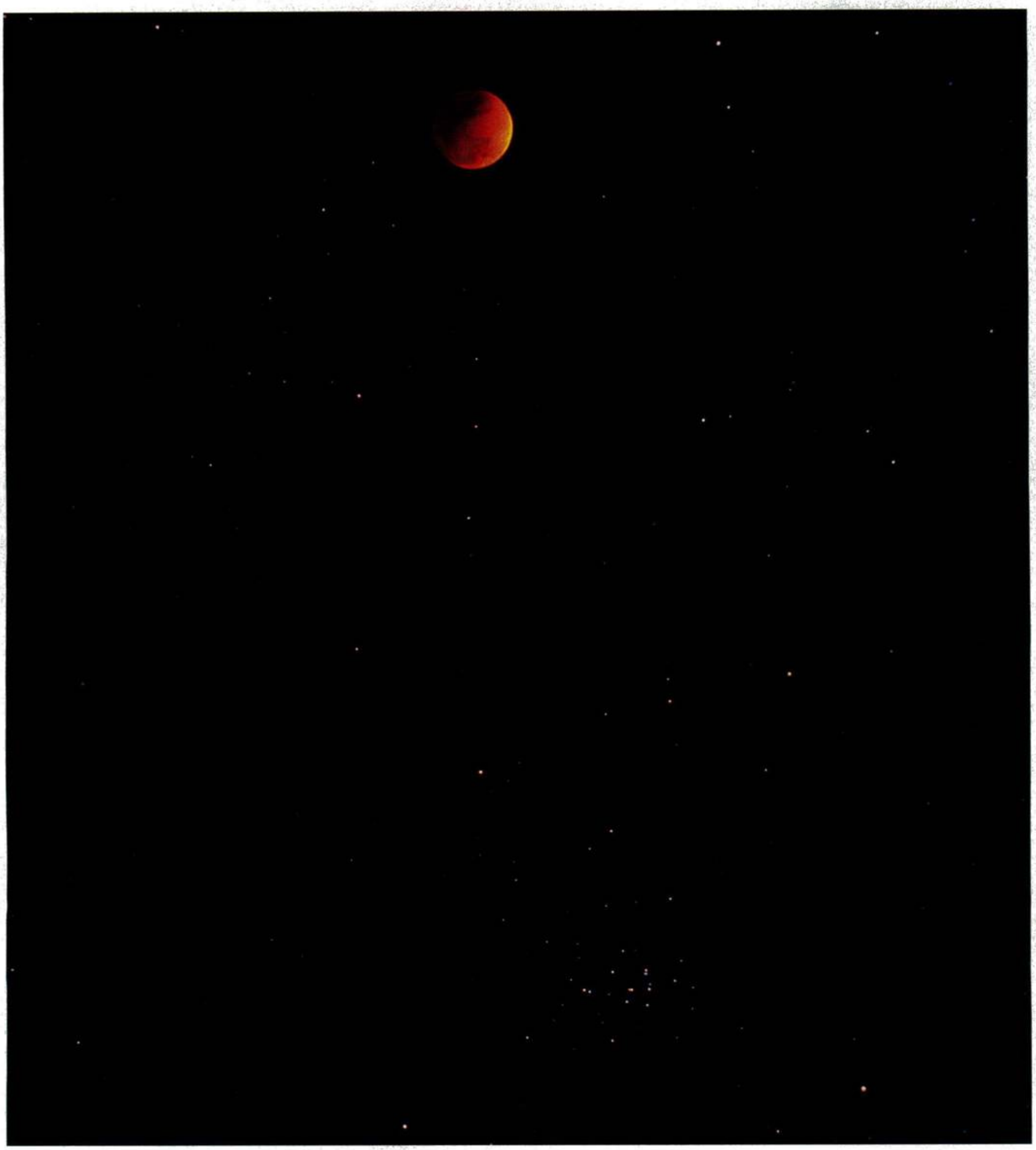


STS-103 Joins Jupiter, Saturn, and the Moon

DEAN O'FLAHERTY

(16mm lens at f/22, Fuji Velvia ISO 50 film, 2-minute exposure taken December 19, 1999)

This month's best astrophoto



The Beehive and the Moon

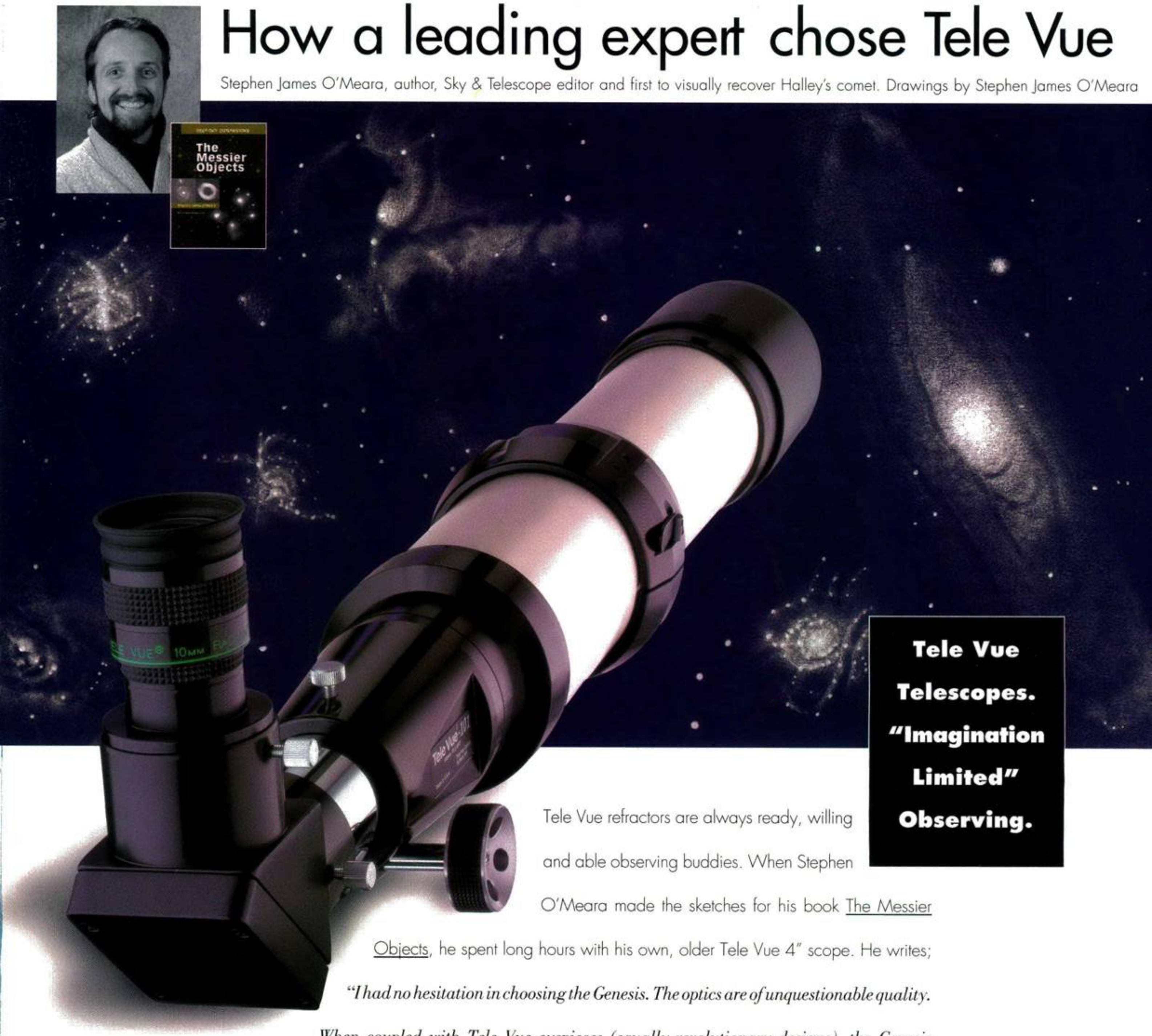
RICHARD MISCHKE

(8-inch SCT at f/4, Ektachrome ISO 400 film, 2-second exposure taken January 20, 2000.)

The path of this year's first lunar eclipse made for an especially photographic moment as it sailed by the Beehive Cluster (M44).

How a leading expert chose Tele Vue

Stephen James O'Meara, author, Sky & Telescope editor and first to visually recover Halley's comet. Drawings by Stephen James O'Meara



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Tele Vue refractors are always ready, willing and able observing buddies. When Stephen O'Meara made the sketches for his book The Messier Objects, he spent long hours with his own, older Tele Vue 4" scope. He writes; *"I had no hesitation in choosing the Genesis. The optics are of unquestionable quality. When coupled with Tele Vue eyepieces (equally revolutionary designs), the Genesis transcends the traditional limitations of long-focus and rich-field refractors, combining the best qualities of both. Genesis and I met serendipitously under dark Texas skies, where I realized its quality and potential. The rest is history."* Stephen discovered a primary virtue of all Tele Vue scopes - versatile performance. Take one along for "imagination limited" observing.

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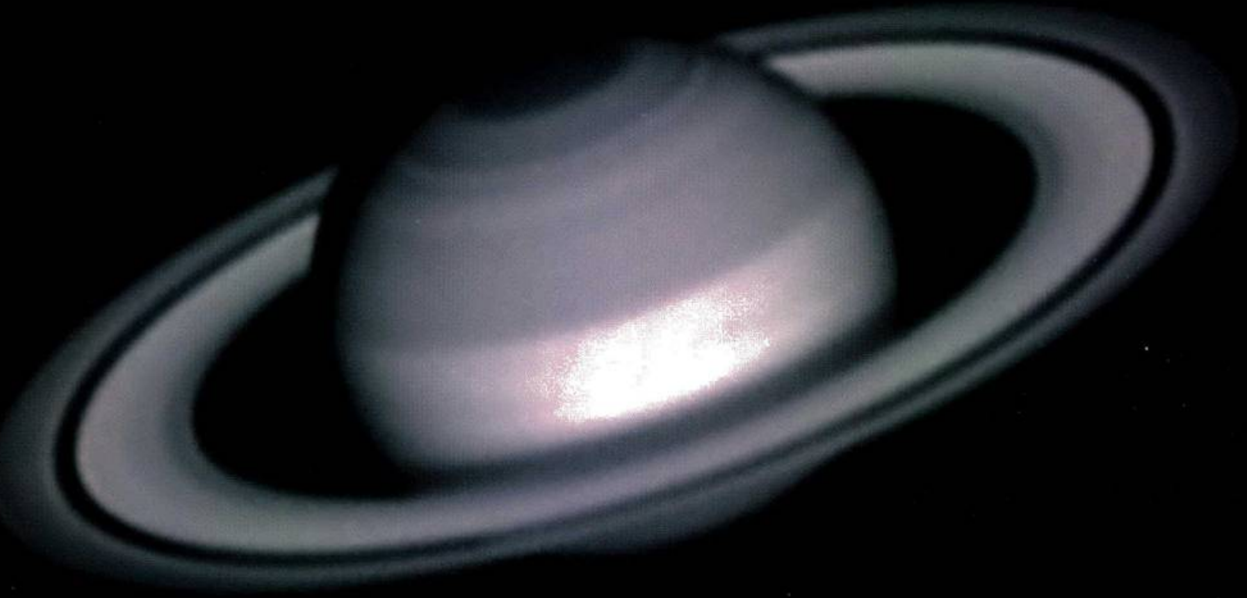

The planet Saturn, October 7, 1999. Thierry Legault of Elancourt, France, obtained this extraordinary image, a composition of fifty 0.5-second CCD exposures at f/39, with the optical system of the Meade 12" LX200 Schmidt-Cassegrain telescope. Comments Mr. Legault: "To my knowledge, this is the first amateur image of Saturn that clearly shows the Encke division — only 0.05 arc seconds wide and located very near the rings' outermost edge, about 80% of the distance from the Cassini division. Several planetary specialists who have seen this image stated that this level of resolution is rare even with professional Earth-based instruments."

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